SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF1

April 21, 2010

SUMMARY INFORMATION

Project ID	EF1
Program Being Evaluated	Enhanced Commercial Industrial Performance Program (ECIPP)
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Museum
Customer Business/Product	n/a

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Chris Zimbelman
Plan Author	Chris Zimbelman

1. PROJECT SUMMARY

The facility is a museum that also has four restaurants on-site that share kitchen facilities. This project involved the installation of two commercial convection ovens in this kitchen. The ovens installed were Blodgett model number DFG-200.

1.1. Savings

Meas. ID	Measure Name		Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Installation of convection ovens*	Reported	0.0	$700
		Evaluated	64.0	n/a
		Realization Rate	n/a	n/a

*It should be noted that this was a prescriptive application and the incentive paid was based on a pre-determined NYSERDA incentive value of $350/unit installed, not an estimated savings value.

1.2. Measure Sampling

Measure sampling is not necessary. All the gas saving equipment installed will be evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	3	$318	
On site M&V	4	$424	
Analysis	6	$636	**Site Evaluation Cost / Incentive**
Report	4	$424	
Total	17	$1,802	257%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID # 1: New Convection Ovens

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

This was an oven replacement with two new convection ovens. The deemed savings for this measure were reported by NYSERDA as zero due to an error in the classification of this oven.

2.1.2. Evaluation Description of Baseline

The ovens that were installed were replacements of existing ovens of the same size that were at the end of their useful life. Therefore, the baseline used to determine the impact for this evaluation was the new construction baseline as defined by NYSERDA in the Deemed Savings Database version 12. This baseline consists of a convection oven with a cooking efficiency of 35% and 2,496 annual operating hours.

2.1.3. Seasonable Variability in Schedule and Production

Oven operation fluctuates with the operating hours of the kitchen and the schedule of museum events. Actual impacts achieved will also vary with these operating hours.

2.1.4. Application Description of As-Built Equipment and Operation

Two Blodgett model DFG-200 full-size dual flow gas convection ovens were installed at the facility. These ovens are in the museum kitchen and are utilized every day by the four restaurants that are present at the facility.

2.1.5. Applicant Energy Savings Algorithms

Due to an error in filing the project application, the application gas savings for this project were equal to zero. Although this was a gas efficiency project, incentives were awarded for an electric convection oven, and therefore no therm savings were claimed by the program.

If the measure impacts had been correctly determined as gas savings, deemed savings values would have been used, meaning the savings would have been based on a predetermined therm/unit basis rather than actual energy savings for the installed equipment. Savings estimations would have been based on convection ovens with a baseline cooking efficiency of 35% and a proposed cooking efficiency of 45% along with 2,496 annual operating hours.

2.1.6. Evaluation Energy Savings Algorithms

This is a verification-level evaluation. Evaluators used information obtained via a site visit, along with published information on the baseline and proposed ovens to calculate the impact of the installation of the two new Blodgett DFG-200 ovens.

Annual gas impacts for this measure are directly related to the amount of food produced annually by the ovens. Due to the fact that kitchen operations were the same in the baseline and proposed cases, evaluators assumed that the amount of food produced annually by the baseline and the proposed ovens did not change. This was verified through conversations with site staff during the site visit.

Baseline energy consumption was calculated using the baseline oven efficiency, along with operating hours of the kitchen and an estimated throughput of food that was based on conversations with facility staff about typical oven operation. The equation for the daily baseline energy consumption is as follows:

> **Daily gas use** (Btu/day) = (**oven pre-heat energy** (Btu) + (**oven throughput** (lbs/hr) * **energy to food** (Btu/lb) * **operating hours** (hrs/day) / **oven efficiency**

The daily gas energy use was then used in conjunction with operating days per year to achieve the total annual energy consumption.

> **Annual gas use** (therms/yr) = **daily gas use** (Btu/day) * **annual operation** (days/yr) * 1 therm /100,000 Btu

There are four restaurants that share this same kitchen. According to facility staff, there is virtually always someone using this oven during the kitchen operating hours, which are 6 AM – 11 PM, 7 days/week. The facility also indicated they thought the estimated throughput for these ovens was between 50 and 100 lbs/hr. The evaluators used 60 lbs/hr as the throughput for these calculations. The baseline efficiency estimate is based on the new construction baseline used by NYSERDA in the Deemed Savings Database version 12. The baseline energy calculation is summarized in the table below:

Table 1: Baseline Energy Consumption

Baseline Oven		
Oven Burner Rating		
Input rating per oven*	60,000	Btu/hr
Quantity of ovens	2	
Total input rating	**120,000**	**Btu/hr**
Energy Use Calculation		
Preheat energy required	19,000	Btu
Oven cooking efficiency	35%	
Oven throughput	60	lbs/hr
Energy to food	250	Btu/lb
Daily oven energy use	782,857	Btu/day
Annual natural gas energy use	**2,818**	**therms/yr**

*Note: Oven input rating was taken from manuf. cut sheet

Because production remains constant, the annual energy transferred to the food was assumed to remain constant. The same equations detailed above were used to calculate the annual energy consumption for the installed oven.

This proposed energy use is summarized in the table below:

Table 2: Proposed Energy Consumption

Installed Oven: Blodgett Model DFG-200		
Oven Burner Rating		
Input rating per oven*	60,000	Btu/hr
Quantity of ovens	2	
Total input rating	**120,000**	**Btu/hr**
Energy Use Calculation		
Preheat energy required	11,200	Btu
Oven cooking efficiency	44%	
Oven throughput (lbs/hr)	60	lbs/hr
Energy to food (Btu/lb)	250	Btu/lb
Daily oven energy use	605,000	Btu/day
Annual natural gas energy use	**2,178**	**therms/yr**

*Note: Oven input rating was taken from manuf. cut sheet

The calculated energy savings were the difference between the two scenarios:

2,818 therms/yr – 2,178 therms/yr = 640 **therms/year of annual natural gas savings**

As mentioned above, the savings reported for this measure by NYSERDA were 0 therms/year, therefore a realization rate could not be calculated for this measure.

2.1.7. Data Measurement

Interview, inspect, and perform spot measurements as needed to:

- Verify measure installation
- Collect nameplate data
- Ask if equipment is operating properly
- Verify values of important variables
- Verify oven is natural gas fired

2.1.8. Site Sampling Strategy

Sampling is not required for this measure.

2.1.9. Uncertainties

Uncertainties arise due to multiple factors:

- Actual operation of these ovens varies with the amount of customers at each restaurant. Calculations are based on best estimates derived from conversations with facility staff and not load measurement.

Overall expected engineering accuracy including metering accuracy and uncertainties: 15%

2.1.10. Non Energy Impacts

There are no non-energy impacts for this measure.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

This oven was classified as an electric oven under the NYSERDA Enhanced Commercial Industrial Performance Program, PON 1101. Therefore, the incentive per unit ($350 /unit) was paid as if this was an electric oven, even though project funding was pulled from the gas efficiency program. This caused NYSERDA to report savings of 0 therms/year for this measure with respect to the gas efficiency program. Due to this fact, 100% of the impact determined in this evaluation is a deviation from the predicted savings.

Evaluators believe this facility uses these two convection ovens significantly more than a typical facility would, which is the primary reason savings exceeded the program deemed savings estimate.

3.2. Deviations from Plan

There were no deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that the program implementers ensure that pre-qualified incentives be properly qualified in the program in order to maximize the benefit for everyone involved. In this case the incentive paid was actually less than the incentive the customer was eligible for, and the program reported savings were zero.

3.4. Customer Alert

The contact listed in the program documentation is no longer with the company.

3.5. Contextual Data

Not applicable for verification sites.

3.6. Evaluation Dates

Assignment date	
Plan approval date	2/2/10
Site visit date(s)	2/5/10
Draft site report completion date	3/19/10

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF10 & LF33

May 11, 2010

SUMMARY INFORMATION

Project ID	EF10 & LF33
Program Being Evaluated	New York Energy Smart – Loan Fund
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial/Laundry

Principal Site Contact	
Title	
Phone	
Email	

NYSERDA Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	
Phone	
Email	

Lead Evaluation Engineer	Satyen Moray
Plan/Report Author	Satyen Moray

1. PROJECT SUMMARY

The facility is a 9,764 square foot industrial dry cleaning facility located in Long Island City, New York. This project was offered a subsidy by NYSERDA on their loan with Citibank for the portion of the costs associated with installing energy efficient equipment at their facility. An energy audit identified numerous measures that had been installed at the facility. The projects included installing high performance T8 lighting, lighting occupancy controls, pipe insulation, air source heat pumps, and replacing old dry cleaning equipment with new equipment that is more efficient and offers a higher production rate than the equipment it replaced.

This gas evaluation is focused on the project associated with the replacement of the dry cleaning equipment. The dry cleaning project involved replacing the existing two 80-lb perc units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit, one 60-lb hydrocarbon unit.

The facility is a commercial dry cleaning operation. The facility operates 11 hours per day for 5 days and occasionally on weekends.

1.1. Savings

ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Install energy efficient dry cleaning equipment	Reported	0*	0	985	$14,776
		Evaluated	n/a	n/a	152	n/a
		Realization Rate	n/a	n/a	15%	n/a

* Reported electricity savings associated with the measure of 181 MWh/yr (PA), 167 MWh/yr (OPC review), and 52 MWh/yr (Approved) exceeds 10% of the gas savings on a Btu basis and thus would have been considered in the scope of this evaluation but NYSERDA already claimed this savings through the SBCIII-funded ECIPP PO8881.

SAIC reviewed the application for accuracy and found the information supplied by the applicant to be accurate. The energy savings details were supplied by the vendor (Columbia Drycleaning Services). SAIC reviewed the pricing for this measure and referenced technical data for the base case and new equipment from the manufacturer’s cut sheets for each piece of equipment. SAIC was also provided with utility bills that were used to calculate the measure savings. However, SAIC savings do not match the savings calculations performed by the Columbia Drycleaning Services staff. SAIC analysis estimated gas savings of 424 MMBtu per year and electric savings of 167,344 kWh per year and peak demand reduction of 16.4 kW. The Columbia Drycleaning Services analysis reports gas savings of 985 MMBtu per year with no information presented on the electric savings. NYSERDA’s reported savings matches Columbia Drycleaning Services’ lower value. The dry cleaning measure had a reported cost of $346,442.

1.2. Measure Sampling

Since the project involved a single measure, sampling is not necessary to evaluate the savings.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	$2,048	
On site M&V	16	$3,023	
Analysis	32	$4,096	**Site Evaluation Cost / Incentive**
Report	12	$1,536	
Total	76	$10,703	72%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The measure involved replacing two existing 80-lb perc (the solvent used is typically tetrachloroethylene, or perchloroethylene, abbreviated "perc") units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit and one 60-lb hydrocarbon unit.

This existing system was composed of two perc systems each with three solvent holding tanks with a total capacity of 215 gallons, a distillation unit of 90 gallons per hour using approximately 6 gpm of chilled water in the process. The two perc units had a combined processing capacity of 160 lbs with an average cycle time of 60 minutes.

The existing hydrocarbon dry cleaning unit has an output of 80 lbs with an average processing time of 90 minutes.

The performance characteristics of the existing perc systems and the hydrocarbon dry cleaning system are listed below:

	Union Perc System	Hoyt (Dry Cleaning)
Output (lbs/cycle)	160	80
Average cycle time (minutes/cycle)	60	90
Production rate (lb/min)	2.7	0.9
Chilled water (gpm) at 50 F	2x6	10
Chilled water (gallons/cycle)	720	900
Steam consumption (lbs/cycle)	2x78	100
Electric consumption (kWh/cycle)	21.9	22.1

The submitted analysis indicated that the existing equipment operated more than 8,580 hours per year.

The project documentation did not have manufacturer's cut sheet for the old or new dry cleaning equipment models and an internet search did not yield any additional details.

The SAIC review letter (PO 8881) dated April 8, 2008, researched and found that the Union Perc machine cut sheets indicated steam use per cycle of 78 lbs and the Hoyt machine cut sheet indicated steam use per cycle of 100 lbs instead of the 80 lbs used in the analysis.

However, SAIC in their review process had confirmed some of the performance information on these units.

2.1.2. Evaluation Description of Baseline

The baseline for this measure is considered to be the same as described in previous section. Even though the new dry cleaning machines offer slightly higher productivity under the current environment, the current production loads are 73% of the 2007 levels.

2.1.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility operations are not weather dependent. However general economic conditions have affected the overall business as the facility staff indicated that they are processing less than their production levels several years ago.

2.1.4. Application Description of As-Built Equipment and Operation

The measure involved replacing two existing 80-lb perc units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit, one 60-lb hydrocarbon unit.

The TD Mach 2.8/2.5 tandem perc system is composed of three sections: two washing and drying sections that utilize one central filtration and distillation section. The first washing and drying section (2.8) is composed of two solvent holding tanks (74 gallons each). The load capacity of each vessel is 80 lbs dry weight. The second washing and drying section (2.5) is composed of two solvent holding tanks (53 gallons each). The load capacity of each vessel is 50 lbs dry weight. Each of these sections is served by individual refrigeration heat pump modules. The third filtration and distillation section is composed of one solvent holding tank (74 gallons) and a steam heated distiller (130 gallons per hour using 4 gpm of chilled water).

The new perc tandem unit has a rated capacity to process 130 lbs in 35 minutes. Depending on the process cycle, the cycle time can on the new perc machines may vary from 10-40 minutes and was verified by us during the site visit. According to the facility staff, the 37-minute cycle time process is the most commonly used setting on these machines.

The new hydrocarbon dry cleaning system (ILSA Model TL HCS 650 N2) is composed of two sections: a washing and drying section that is connected to a filtration and distillation section. The entire system has four solvent tanks. Two of the tanks have a liquid capacity of 74 gallons each, and the other two tanks have a capacity of 42 gallons each. The load capacity is 60 lbs dry weight. The new hydrocarbon dry cleaning unit has a rated capacity to process 60 lbs in 35 minutes. Again depending on the process cycle, the cycle time may vary between 38-48 minutes, which we verified during the site visit. According to the facility staff, the 38-minute cycle time process is the most commonly used setting on these machines.

The performance characteristics of the tandem perc system and the hydrocarbon dry cleaning system are listed below:

	TD MACH 2.8/2.5 Tandem	TL HCS 650
Output (lbs/cycle)	130	60
Avg cycle time (minutes/cycle)	35	60
Production rate (lb/min)	3.7	1.0
Chilled water (gpm) at 50 F	4.6	3
Chilled water (gallons/cycle)	161	180
Steam consumption (lbs/cycle)	99	68
Electric consumption (kWh/cycle)	10.58	12.1

As noted previously, electric savings evaluation is not in scope.

One 30-hp steam boiler supplies steam at 100 psig to the facility. No information on the actual tested boiler system efficiency was provided in the documentation.

The SAIC review letter (PO 8881) dated April 8, 2008, specified that specific performance for the new equipment was requested and was provided based on a test conducted by a Columbia engineer in Germany. The data indicated 99 lbs of steam per cycle for the tandem perc machine (TD MACH 2.8/2.5) and 68 lbs of steam for the hydrocarbon unit (TL HCS 650) compared to the 66 lbs of steam for both the machines indicated in the earlier submitted documents.

One Fulton boiler (Model FB-030-A) generates steam at 100 psig for use in the process and was tested to operate at an efficiency of 74% (6.8% oxygen and 605°F stack temperature). This tested efficiency was used in our analysis.

The original analysis used an estimated efficiency of 70% and system losses of 10% in its calculation.

The equipment operation was confirmed and found to be operational during the site visit.

2.1.5. Measure Life

Specific measure life details are not available for the dry cleaning equipment.

2.1.6. Applicant Energy Savings Algorithms

The original savings reported were calculated using equipment nameplate data as follows:

The steam consumption (lbs and BHP) per cycle for the base case equipment and the new equipment was used. A 10% heat loss factor and a 70% efficiency factor were used to estimate the overall steam load for the old and new equipment options. The general equation for the two options was:

Boiler Load (BHP) = Steam Load (BHP) x Heat Loss Factor (10%) / Efficiency Factor (70%)

Based on the production rates, a production efficiency factor was also determined:

Production Efficiency Factor = New Equipment Production Rate (lbs/min) / Old Equipment Production Rate (lbs/min)

Boiler gas use per hour for the old and new equipment was then calculated using the following equations:

Old Equipment Gas Use (therm/hr): 42 ft^3/hr x Old Boiler Load BHP x 1000 btu/ft^3 / 100,000 Btu/therm

New Equipment Gas Use (therms/hr): 42 ft^3/hr x New Boiler BHP x 1000 btu/ft^3 / 100,000 Btu/therm

The gas use rates for the two options were then multiplied by 8,580 annual operating hours. The new equipment gas use was discounted by production rate at which the laundry is processed. The basis for using a processing rate of 4,750 lbs of linen per hour was not described in the project documentation.

The operating hours were calculated by multiplying the hours per days by number of days per week and weeks per year.

The conventional (baseline) and continuous (as-built) dry cleaning equipment performance data (as described in sections above) was used to calculate the water and steam saved.

The water to be evaporated was calculated and was then multiplied by the difference in baseline and as-built system energy of evaporation to determine the direct gas savings (from water savings). The source for the numbers used in this calculation was not adequately described in the project documentation.

The difference between the baseline and as-built system steam usage per pound of laundry processed was multiplied by the total annual pounds of laundry processed to obtain the savings from reduced steam usage. This value was divided by boiler efficiency.

Electric energy and demand savings were calculated but are considered beyond the scope of this evaluation.

2.1.7. Evaluation Energy Savings Algorithms

The evaluators adjusted the analysis methodology compared to the original algorithms. The key equations used to assess the impact of this measure are:

Steam Use Factor (SUF) = Steam Use Per Cycle (lbs/cycle) / Laundry Load Per Cycle (lbs/cycle)

The above factors are derived from equipment cut sheets.

Max Number of Process Cycles Per Week (MC) (cycles/week) = Equipment Runtime Per Week / Cycle Time

The equipment runtime per week was determined from logged data for the tandem perc unit and the hydrocarbon unit. The cycle time is based on information provided by facility staff and based on field notes.

Actual Number of Process Cycles Per Week (AC) (cycles/week) = MC x Duty Factor

Duty factor is based on logged data. Based on the log data profile, we counted the number of process cycles that occurred during the logging period.

Steam Load Per Week (lbs/week) = AC x Laundry Load Per Cycle x SUF

Production Proration Factor (PRF) = 1.15

This PRF factor was calculated using annual production data provided by the facility staff for the past 3 years and the production data for the month of January 2010. The facility production does increase during the warmer summer/fall months. The facility staff did not track monthly production data with the exception of the January 2010 data that was provided to us based on our earlier request. In 2009, the annual production in the facility was 137,058 units while in the month of January 2010, the production was 9,913 units. Therefore, assuming constant monthly production, the projected annual production using the January 2010 data would be 9,913 units/month x 12 months/yr = 118,956 units/yr. Assuming that 2010 would be similar to 2009, then the production would need to adjusted by a factor = 137,058 / 118,956 = 1.15.

Annual Steam Load (lbs/yr) = Steam Used Per Week x PRF x 52 weeks/yr

Annual Boiler Load (therms/yr) = Annual Steam Load (lbs/yr) x Boiler Delta Enthalpy (Btu/lb) / (Boiler Efficiency x 1000,000 (Btu/therm))

Boiler delta enthalpy was calculated as 1,022 Btu/lb based on feed water entering the boiler at 200°F (168 Btu/lb) and the boiler generating saturated steam at 100 psig (1,190 Btu/lb). The boiler efficiency was tested using a combustion analyzer at 74%.

The table below presents the savings analysis details

HYDROCARBON UNIT ANALYSIS		
	TL HCS 650	**Existing (Hoyt)**
Output (lbs/cycle)	60	80
Average cycle time (minutes/cycle)	38	90
Production rate (lb/min)	1.6	0.9
Steam use - lbs/cycle	68	100
lbs steam / lbs laundry	1.13	1.25
Runtime per week (from logger)	38	
Max no. of cycles	60	
Duty factor	60%	
Actual cycles	36	27
lbs laundry processed per week	2,174	2,174
lbs steam used per week	2,464	2,718
Production proration factor	1.15	1.15
lbs laundry processed per year	130,018	130,018
lbs steam used per year	147,353	162,522
Steam Savings		
Steam (lbs/yr)	15,169	
Steam enthalpy (Btu/lb)	1,190	
Feed water enthalpy (Btu/lb)	168	
Boiler delta enthalpy (Btu/lb)	1,022	
Boiler load (therms/yr)	155	
Boiler efficiency	74%	
Natural gas savings (therms/yr)	209	

PERC UNIT ANALYSIS		
	TD MACH 2.8/2.5 Tandem	**Existing (2 Pieces)**
Output (lbs/cycle)	130	160
Average cycle time (minutes/cycle)	37	60
Production rate (lb/min)	3.5	2.7
Steam use - lbs/cycle	99	156
lbs steam / lbs laundry	0.76	0.98
Runtime per week for 2.8 (from logger)	51	
Runtime per week for 2.5 (from logger)	50	
Average Runtime per week	51	
Max no. of Cycles	82	
Duty factor	70%	
Actual cycles	57	47
lbs laundry processed per week	7,452	7,452
lbs steam used per week	5,675	7,266
Production proration factor	1.15	1.15
lbs laundry processed per year	445,639	445,639
lbs steam used per year	339,371	434,498
Steam Savings		
Steam (lbs/yr)	95,127	
Steam enthalpy (Btu/lb)	1,190	
Feed water enthalpy (Btu/lb)	168	
Boiler delta enthalpy (Btu/lb)	1,022	
Boiler load (therms/yr)	972	
Boiler efficiency	74%	
Natural gas savings (therms/yr)	1,314	

Evaluated Savings

The table below presents the evaluated savings and the overall project realization rate.

Evaluated Savings	
Perc unit savings (therms/yr)	209
Hydrocarbon unit savings (therms/yr)	1,314
Total savings (therms/yr)	**1,523**
Original Application Savings	
Perc unit savings (therms/yr)	6,595
Hydrocarbon unit savings (therms/yr)	3,256
Total savings (therms/yr)	**9,851**
Realization Rate	**15%**

A combination of the factors listed below contributed to the difference between the evaluated savings and the original savings.

- The original analysis used 8,580 hours/yr for the old and new units while the logged (actual) hours of operation for the new equipment ranges from 2,000 to 2,500 hours per year.
- The boiler efficiency is slightly better than claimed in the original analysis.
- The original analysis did not account for the steam used by the second part of the tandem perc unit. The original analysis only used 66 lbs per cycle while the overall steam for the new tandem perc machine is 99 lbs per cycle.
- The operating cycle times for the new equipment were observed to be slightly higher than predicted in the original analysis.

2.1.8. Data Measurement Method

Complete the table for each variable noted as being measured in the prior section.

Equipment monitored	Boilers	Perc and Hydrocarbon Machine
Parameter measured	Combustion efficiency	Operating hours
Measurement equipment	Combustion analyzer	Interview with the site staff & manufacturer; amp loggers; and onsite observations
Observation frequency	Spot measurement	30 seconds
Metering duration	N/A	2 weeks
Accuracy	± 1 % reading	± 1 % reading

2.1.9. Site Sampling Strategy

Sampling strategy is not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation, the analysis was conducted for weekly production which was scaled up to determine the annual consumption.

Overall expected engineering accuracy including metering accuracy and uncertainties: 25%

2.1.11. Non-Energy Impacts

After a certain number of cycles, the perc (chemical) used in the dry cleaning process is disposed as a hazardous waste which requires special handling. According to the facility staff, installing the new perc machines significantly reduced the number of hazardous waste barrels generated at the facility as the new machines are able to efficiently recover most of the perc. According to anecdotal information provided by the facility staff, on an average the base case perc machines generated 1,800 lbs of hazardous waste per month and the new perc machines are generating hazardous waste at a rate of 700-800 lbs per month. The waste is typically hauled away in 55-gallon containers at an average price of about $330 per barrel. The density of perc is 13.5 lbs per gallon. However, the waste containers are also filled with filters and other solid waste, so we increased the density by 25%. Table below shows the hazardous waste reduction cost savings that resulted from implementing this project.

	Base case	**Post case**	**Savings**
Average waste produced (lbs/mo)	1,800	750	1,050
Average waste produced (gallons/mo)	133	56	78
Number of barrels per mo	2.4	1.0	1.4
Cost per barrel	$330	$330	
Annual waste disposal cost ($/yr)	$9,592	$3,997	$5,596

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The application savings calculations overestimated due to a number of factors, which are listed below.

- The original analysis used 8,580 hours/yr for the old and new equipment while the logged (actual) hours of operation for the new equipment ranges from 2,000 to 2,500 hours per year, a 77% drop.
- The boiler efficiency is slightly better than claimed in the original analysis.
- The original analysis did not account for the steam used by the second part of the tandem perc unit. The original analysis only used 66 lbs per cycle while the overall steam for the new tandem perc machine is 99 lbs per cycle.
- The operating cycle times for the new equipment were observed to be slightly higher than predicted in the original analysis.

A combination of these factors resulted in a realization rate of 15%.

3.2. Deviations from M&V Plan

None.

3.3. Recommendations for Program Designers & Implementers

This measure has an efficiency and productivity component that makes the analysis slightly complicated. The evaluators recommend care or precaution when working with these types of measures or installations as they tend to either miss the productivity element of the analysis or the energy element when the intent should be on accurately estimating the impact of both.

3.4. Customer Alert

The site has limited staff availability.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	
Building predominant year of construction	

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/25/2010
Site visit date(s)	2/8/2010, 3/19/2010, 3/31/2010
Draft site report completion date	4/19/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheet

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified

Contract ID	EF11
Site Name	EF11
NYSERDA Program Component	SEC/ECIPP Tier I
Site Contact	
Site Address	
Nexant Project Reviewer	Mark Maloney & Salil Gogte
Nexant Project Inspector	Salil Gogte
Inspection Date and Time	7/2/08 10:30am

Measure Description	**High Efficiency Condensing Boilers**	
	NYSERDA	**Nexant/ERS**
Boiler Manufacturer	AERCO	AERCO
Boiler Model	BMK-2.0 GWB	BMK-2.0 GWB
Boiler Input Capacity, kBtu/hr	2,000	2,000
Boiler Quantity	8	8
Boiler Fuel	Natural Gas	Natural Gas
Hot Water End Use	space heating	space heating
Baseline MMBtu Consumption - 1 electric boiler (*electric MMBtu equivalent*)	-	9,355
Retrofit MMBtu Consumption	-	8,091
MMBtu Savings	724	1,264

Measure Description	**Domestic Hot Water Heater**	
	NYSERDA	**Nexant/ERS**
Heater Manufacturer	AERCO	AERCO
Heater Model	KC-1000 GWW	KC-1000 GWW
Heater Input Capacity, kBtu/hr	1,000	1,000
Heater Quantity	1	1
Heater Fuel	Natural Gas	Natural Gas
Hot Water End Use	Domestic	Domestic
Baseline MMBtu Consumption - 3 electric heaters, 1 backup (*electric MMBtu equivalent*)		712
Retrofit MMBtu Consumption		613
MMBtu Savings	6	99

Measure Description	**Pipe Insulation**	
	NYSERDA	**Nexant/ERS**
Insulation Manufacturer	Knauf	Knauf
Total Insulation Length, Feet	700	700
Insulation Thickness of 2.5" diameter pipe, Inches	1.5	1.5
Insulation Thickness of 2" diameter pipe, Inches	2	2
% of piping at 2.5" diameter	N/A	0.75
% of piping at 3" diameter	N/A	0.25
Supply Temperature, space heating (°F)	N/A	122
Hours of Operation, space heating	N/A	3,122
MMBtu Savings	483.7	132

Gas MMBtu Savings	1,214	1,495
Gross Gas Realization Rate	-	123%

Inspection and Review Notes:	1. One electric boiler was replaced by 8 identical gas-fired condensing boilers. The boilers are 2. Two 120 kW domestic hot water heaters were replaced by a gas heater with 93% efficiency and 3. Insulation was placed on 700 ft of steel piping exiting the boilers. About 75% of this piping is 2.5 inch, with 1.5 inch insulation, and the remainder is 3 inch with 2 inch insulation. Boiler water temperature varies from 115-130 deg F and the room temperature is typically 76-80 deg F. 4. The facilty has two independent gas meters for DHW and space heating (boilers). Billing data is shown on the right. The 2007 heating therms are indicative of the gas consumption for the 8

ERS Notes	1. Updated installed boiler & DHW heater efficiency to be consistent with boiler efficiency determined via the Boiler Study that was performed at this site as a part of this evaluation.

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	EF12
Site Name	EF12
Project Close Date	11/20/2006
NYSERDA Program Component	
Nexant Project Reviewer	Angela Patnode
Nexant Project Inspector	Angela Patnode
Inspection Date and Time	3/14/2007 @ 1:30 PM

Measure Description [1]	**High-Efficiency Boilers (Steam)**			
	NYSERDA	**Nexant**	**ERS- Gas Impacts**	**ERS - Oil Impacts**
Boiler Manufacturer #1	Weil-McLain	Weil-McLain	Weil-McLain	-
Boiler Model #1 [2]	H-2494	H-2494	H-2494	-
Boiler Input Capacity #1, kBtu/hr	8299	8299	8299	-
Boiler Gross Output #1, kBtu/hr	6680	6680	6680	-
Boiler Quantity #1	2	2	2	-
Boiler #1 Fuel		dual fuel (oil or natural gas)	dual fuel (oil or natural gas)	-
Boiler Manufacturer #2	Weil-McLain	Weil-McLain	Weil-McLain	-
Boiler Model #2 2	H-2194	H-2194	H-2194	-
Boiler Input Capacity #2, kBtu/hr	7216	7216	7216	-
Boiler Gross Output #2, kBtu/hr	5810	5810	5810	-
Boiler Quantity #2	1	1	1	-
Boiler #2 Fuel		dual fuel (oil or natural gas)	dual fuel (oil or natural gas)	-
Quantity of Previous Boilers		3	3	-
Age of Previous Boilers, years		54	54	-
Est. Efficiency of Previous Boilers [3]		0.78	0.78	-
Fuel of Previous Boilers		#6 oil and natural gas	#6 oil and natural gas	-
Boiler Installation Date	June-July 2006	June-July 2006	June-July 2006	-
Gas Consumption from October 2006 - March 2007, Therm/yr		91798.000	91,798	-
Estimated Fuel Ratio for Past Heating Season, Therms Oil/Therm Gas [4]		3	3	-
Estimated Fuel Oil Consumption, October 2006 - March 2007, Therm/yr		275394	275,394	-
Typical Heating Degree Days, October-March		4218	4218	-
Typical Heating Degree Days, October-May		4714	4714	-
Anticipated Total Therm Consumption, October 2006-May 2007		410371	102,593	307,778
Therm Output at Installed Boiler Efficiency		330314	82,578	247,735
Baseline Input at Estimated Baseline Boiler Efficiency		423479	105,870	317,610
Therm Savings, Space Heating		13109	3,277	9,832
Gas Consumption from June 2005 - September 2005 [5]		54336	54,336	-
Therm Output at Estimated Baseline Boiler Efficiency		42382	42,382	-
Estimated Input at Installed Boiler Efficiency		52654	52,654	-
Therm Savings, DHW Heating		1682	1,682	-
MMBtu Savings	2138	1479	496	983

Measure Description [7]		Pipe Insulation		
Insulation Manufacturer	Johns Manville		Johns Manville	-
Insulation Brand	Micro-Lok		Micro-Lok	-
Total Insulation Length, Feet	2,161		2,161	-
Pipe Diameter, Inches	14" to 3"		14" to 3"	-
Insulation Thickness, Inches	2		2" (on 8" diameter pipe and larger) 1.5" (on 4" diameter pipe and smaller)	-
Hours of Operation, Winter	4380		5110	-
Hours of Operation, Summer	0		3650	-
% of Pipe Length Heated in Summer [8]			0.33	-
Steam Pressure, psig			8.5	-
Steam Temperature, F			236	-
Average Annual Ambient Temperature, F			75	-
Average Thermal Conductivity from 75 - 100 F, Btu-in/hr-ft2-F	0.235		0.235	-
Heat Loss from System with Bare Pipe, kBtu/hr [9]			1,135.6	-
Heat Loss from System with Insulated Pipe, kBtu/hr [9]			83.6	-
Total Heat Loss Reduction, MMBtu			2,611.0	4,031.7
Installed Boiler Efficiency			0.805	-
MMBtu Savings	1,493.3		3,243.8	5,008.8
% Adjusted Savings [10]			217.2%	-
Gas MMBtu Savings	3,631.1		3,739.7	-
Gross Gas Realization Rate			103.0%	-
Oil MMBtu Savings			-	5,992.0

Inspection Notes:	1. Facility replaced three original steam boilers (circa 1952) with three new dual-fuel steam boilers. Steam is utilized throughout the year for both space heating and domestic hot water heating 2. Boiler nameplate could not be found on any of the boilers; boiler model was identified by measuring boiler length and comparing with manufacturer specifications sheet 3. Baseline efficiency of steam boilers greater than 2,500 kBtuh, from Deemed Savings Database (source: FEMP) 4. Facility contact estimates that for the past heating season, fuel mix has been roughly 75% fuel oil, 25% natural gas; mix will vary with price of each fuel 5. Facility contact reports that, in general, natural gas is the primary fuel during summer use; savings are conservatively estimated assuming no fuel oil during summer baseline period 6. Verified savings are less than stipulated savings because stipulated savings are based on an increase in boiler efficiency to 83%; installed boiler efficiency is 80.5% 7. Site contact confirmed that the baseline piping was bare (no insulation) prior to the project 8. The portion of the distribution piping which runs to the domestic hot water heat exchangers is heated throughout the summer months as well as in the winter 9. All heat loss calculations obtained from 3E Plus software using process temperatures, ambient temperatures, total length, pipe diameters, thermal conductivity, and insulation thicknesses disclosed above. From insulation invoice, insulation applied was 42 ft of 14" diameter pipe, 180 ft of 12" diameter pipe, 74 ft of 8" diameter pipe, 840 ft of 6" diameter pipe, 295 ft of 4" diameter pipe, and 730 ft of 3" diameter pipe. 10. Savings are greater than stipulated because stipulated savings are based on a diameter of 4", whereas the majority of the piping insulated was of diameter 6" and greater; savings are also increased given that a portion of the piping that runs to the domestic hot water heat exchangers is in use all year

ERS Review Notes	1. Natural gas and oil impacts are accounted for seperately.
	2. Based on the (1/3) gas/oil ratio, we separated the gas usage from oil usage. Savings are presented for each type of fuel.

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	EF13
Site Name	EF13
Nexant Project Reviewer	Angela Patnode & Salil Gogte
Nexant Project Inspector	Salil Gogte
Inspection Date and Time	6/1/2007

Measure Description	**High-Efficiency Boiler (Hot Water)**	
	NYSERDA	**ERS**
Boiler Manufacturer	Aerco	Aerco
Boiler Model	BMK 2.0 GWB	BMK 2.0 GWB431NF28
Boiler Quantity	7	7
Boiler Fuel	natural gas	natural gas
Boiler Rating, input (kBtu/h)	2,000	2,000
Boiler Rating, output (kBtu/hr)	1,720	1,780
Installed Boiler Efficiency	86%	89%
Baseline Boiler Efficiency		80%
Post-Install Therms, 12/21/06 - 4/23/07 (space heat + domestic water)		83,136
Post-Install Therms, 4/23/07- 5/22/07 (domestic water heating only)		372
Total Annual Post-Install Therms		129,039
Total Baseline Input (Therms)		143,556
MMBtu Savings	1,267	1,452
Measure Description	**Pipe Insulation**	
Insulation Manufacturer	Knauf	Knauf
Total Insulation Length, Feet	4,800	4,800
Insulation Thickness, Inches	1	1
% of piping at 4" diameter		0.25
% of piping at 2" diameter		0.50
% of piping at 1" diameter		0.25
Supply Temperature, space heating (F)		180
Supply Temperature, domestic water (F)		150
Hours of Operation, space heating		4,419
Hours of Operation, domestic water		8,760
Energy Savings, space heating piping, MMBtu		1,285.8
Energy Savings, domestic water piping, MMBtu		1,653.5
Total Heat Loss Reduction, MMBtu		2,939.3
Installed Boiler Efficiency		89.0%
MMBtu Savings	2,534	3,302.6
MMbtu Gas Savings	3,801	4,754
Gross Realization Rate		125%

Inspection Notes:	1. All heat loss calculations obtained from 3E Plus software 2. Therm use based on bills 3. Annual hours for space heating piping are typical hours of year for New York, NY in which outside air is less than 55 F 4. This project is a new construction, hence baseline boiler efficiency is obtained from the ASHRAE Standard

ERS Review Notes	1. The boiler namplate indicates that the output ranges from 1,720-Mbtuh to 1,840-Mbtuh. There is no indication on the return water temperature or the percent firing rate of the boiler. It was estimated that the boiler output was the average of the two values given, or 1,780 Mbtuh, corresponding to a 89% efficient boiler. 2. Conversations with site staff indicated that the supply water temperature was set at 155°F. The analysis has been updated to assume an average temperature drop across the boiler loop of 20°F, and a typical return temperature of 135°F. Conservatively assuming an excess air quantity of 10%, and that the stack temperature is equal to the return water temperature, the efficiency expected for the installed boiler is 89%.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF14

May 30, 2010

SUMMARY INFORMATION

Project ID	EF14		
Program Being Evaluated	EF, Group A		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Recreation center with indoor pool		
Customer Business/Product			

Principal Site Contact			
Title			
Phone		**email**	
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Dakers Gowans
Report Author	Dakers Gowans

1. PROJECT SUMMARY

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Replace 1970 oil fired steam boilers with gas fired boilers	Reported[1]	0	0	4,765	47,650
		Evaluated			7,571	75,709
		Realization Rate			1.59	
2	BAS upgrades	Reported	0	0	0	0
		Evaluated	0	0	0	0
		Realization Rate				
3		Reported				
		Evaluated				
		Realization Rate				
4		Reported				
		Evaluated				
		Realization Rate				
Total		Reported				
		Evaluated				
		Realization Rate				

1.2. Measure Sampling

No sampling will be used for this analysis. The evaluation will take an IPMVP Option C approach using utility bills

1.3. Budget

Task	Hours	Cost Including Expenses
M&V plan	4	$600

[1] Reported values are from database report dated July 30, 2009, which that the project is at the PIR stage. As part of the project documentation ERS received an M&V report with the following recommended savings and incentive values: 7570.9, $75,709.

On site M&V	3	$450	
Analysis	12	$1,800	**Site Evaluation Cost / Incentive**
Report	4	$600	
Total	23	$3,450	5%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	
Replacement of failed equipment	
Replacement of working equipment	X
Industrial process expansion	

Building representative and project documentation state that 2-300HP Scotch marine boilers (oil fired, steam) were removed. Boilers supply space heat and pool heating year round.

2.1.2. Evaluation Description of Baseline

The contractor's project baseline was 12 months of fuel oil billing records 7/04-6/05. The evaluator also obtained fuel deliveries from the building manager for the period 1/06-12/07. For the evaluation analysis the baseline year was set as 1/06 - 12/06. The retrofit occurred in the summer of 2008 and so the 2006 calendar year better captures the building performance just prior to the measure installation.

A baseline model was developed with monthly boiler fuel use regressed against average monthly dry bulb temperature. The model has a high uncertainty with a cvRMSE of 32%; ASHRAE Guideline 14 recommends a cvRMSE of 15% or less for monthly simulation models. Explanations for the high uncertainty include; irregular delivery times (probably delivery on demand), and the time difference between delivery dates and actual fuel consumption. Despite the high uncertainty the model was used as a valid predictor of baseline energy use because of the need to weather-normalize the baseline and because other options such as adjustment by annual HDD are even less reliable.

2.1.3. Seasonable Variability in Schedule and Production

The boilers are used for space, domestic hot water, and swimming pool heating which is driven by seasonal heating loads.

2.1.4. Application Description of As-Built Equipment and Operation

The new equipment consists of 3-138 HP cast iron sectional boilers (gas-fired, steam) with modulating burners, lead/lag sequencing control, and associated equipment such as piping and tanks.

2.1.5. Applicant Energy Savings Algorithms

The ESCO proposed M&V plan was to conduct a degree day adjusted billing analysis. In the implementation of the plan the report appears to be a simple bill comparison between consumption in the M&V period baseline and performance years with no weather adjustment.

2.1.6. Evaluation Energy Savings Algorithms

The evaluation M&V plan is to conduct a billing analysis using the ET software package to construct a 4-parameter baseline model (2006 monthly therm use regressed against average monthly outside drybulb temperature) and to then run the model using actual temperatures during the performance year (2009) to estimate the energy use that would have occurred if the measure had not been installed. Actual fuel use from billing records for the performance year is subtracted from the modeled baseline use, and the difference is the measure savings.

2.1.7. Data Measurement Method

Complete the table for each variable noted as being measured in the prior section.

	Baseline (2006)	Performance (2009)
Equipment monitored	Steam boilers	Replacement steam boilers
Parameter measured	Fuel oil delivery	Natural gas use
Measurement equipment	Fuel oil delivery record from building manager records	Con Edison natural gas billing records
Observation frequency	Monthly for 1 year	Monthly for 1 year
Metering duration	1 year	1 year
Accuracy	Assumed without error	Assumed without error

2.1.8. Site Sampling Strategy

No sampling conducted for this review.

2.1.9. Uncertainties

Billing records are considered completely accurate. Errors occur when building managers fail to account for all accounts, or when billing records are lost; but the bills themselves are assumed without error. Overall expected engineering accuracy including metering accuracy and uncertainties: 100%

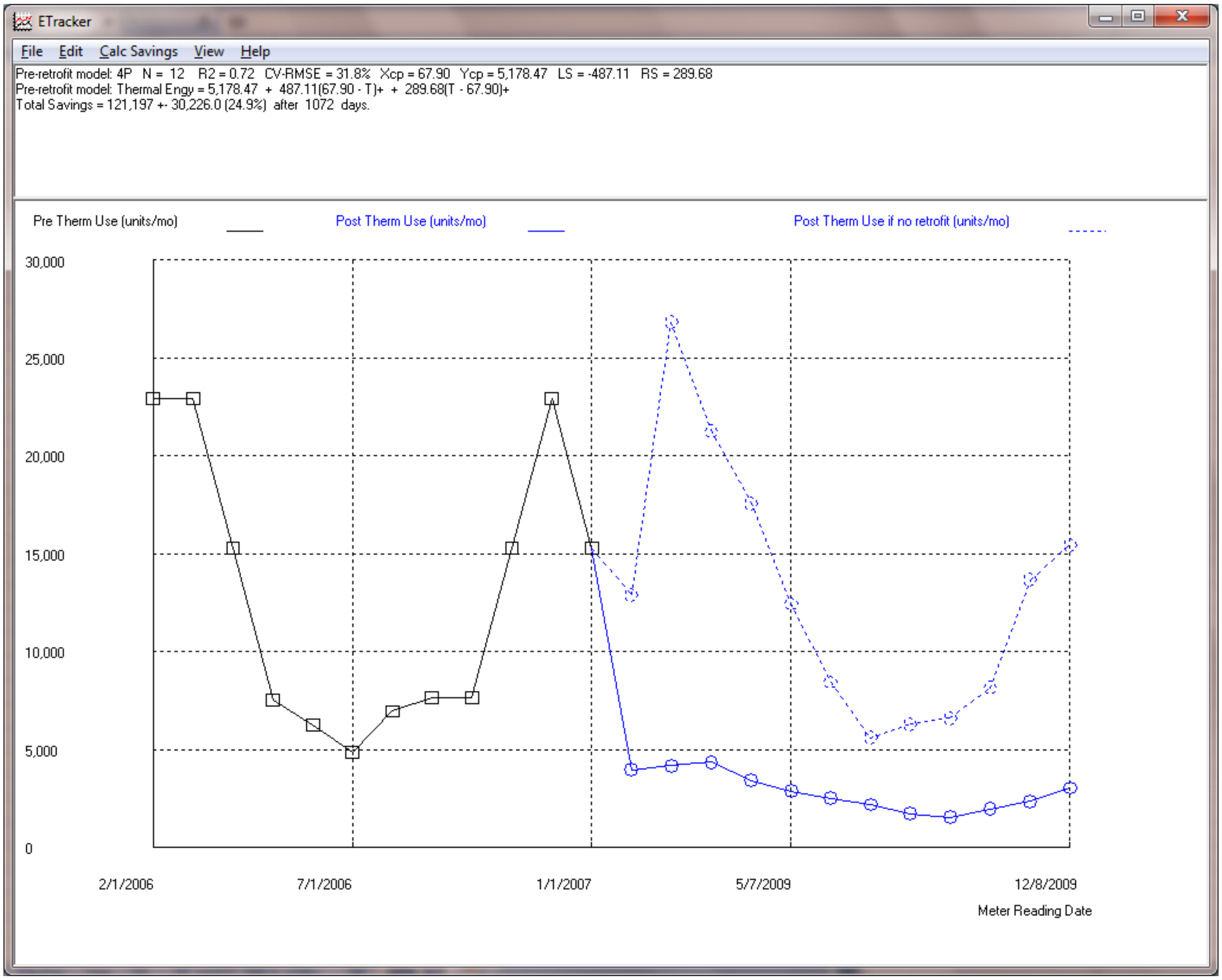
2.1.10. Non-Energy Impacts

The building representative will be queried about any additional effects that he may have observed due to the implementation of the gas measure.

3. EVALUATION REPORT SUPPLEMENT

The natural gas billing records for 2009 were compared to a weather-adjusted, simulated baseline consumption. The simulated baseline was constructed using oil billing records and daily outside air temperature data (at a nearby airport) for 2006. The results are shown graphically below. Additional figures documenting fuel use are appended to this report.

Figure 1: Fuel oil / natural gas use 2006 (baseline) and 2009 (post-retrofit)



The 2009 billed gas consumption was 22% of the simulated baseline consumption. In other words the measure saved 78% of the baseline fuel use. Because the increase in boiler efficiency due to the retrofit was only 14%, a 78% fuel reduction is not physically possible and the modeled savings should not be used.

Part of the increase in savings beyond the simple increase in efficiency may be due to reduced heating load, and to improved control strategies. However, the project did not include any major shell or load reducing measures, and this was confirmed during the interview conducted with the building manager during the site visit. There was a controls measure included in this project though its benefit was mostly on electric use.

The most likely explanation for the discrepancy between savings based on billed fuel use and an engineering estimate is that there is a significant unreported energy accounts. Follow up conversations with the building manager failed to find any missing fuel accounts. The NYSERDA M&V reviewer noted this discrepancy between savings calculated from a bill comparison and the physical limitations on expected savings due to the small increase in boiler efficiency. The NYSERDA reviewer was unable to resolve the discrepancy.

Because the billing analysis results are being discarded, the NYSERDA-reported M&V reported savings are accepted without change for the evaluation.

3.1. Explanation for Deviation

The NYSERDA-reported M&V savings and therefore the evaluated savings for this project differ from the NYSERDA database savings as of July 31, 2009, the date the sample frame was frozen. The reason is that the July 31 database is current for the project through the PIR stage; the M&V savings were approved in August of 2009. The final, approved M&V savings are taken as the best information available at the time of this review and therefore replace the PIR estimated savings.

3.2. Deviations from Plan

The M&V plan was executed as described. The results were not useable.

3.3. Electric Savings Due to Gas Measures

This was a comprehensive project with both electric and gas measures. Electric savings are accounted for separately through the SBC evaluation process. There are no electic impacts associated with the boiler replacement measure.

3.4. Recommendations for Program Designers & Implementers

Energy bills should be collected and checked at each application stage. It is likely that the billing discrepancy could have been resolved when all parties were actively engaged in building and commissioning the project and that the issue of low reported energy usage could have been resolved.

3.5. Customer Alert

The evaluator is not aware of any customer sensitivity issues.

3.6. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	130,000
Building predominant year of construction	1926, 1970

3.7. Evaluation Dates

Assignment date	February 2010
Plan approval date	NA
Site visit date(s)	3/9/10
Draft site report completion date	5/30/10

3.8. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

Figure 2: Fuel oil / natural gas use 2006, 2009 as a function of outside air temperature

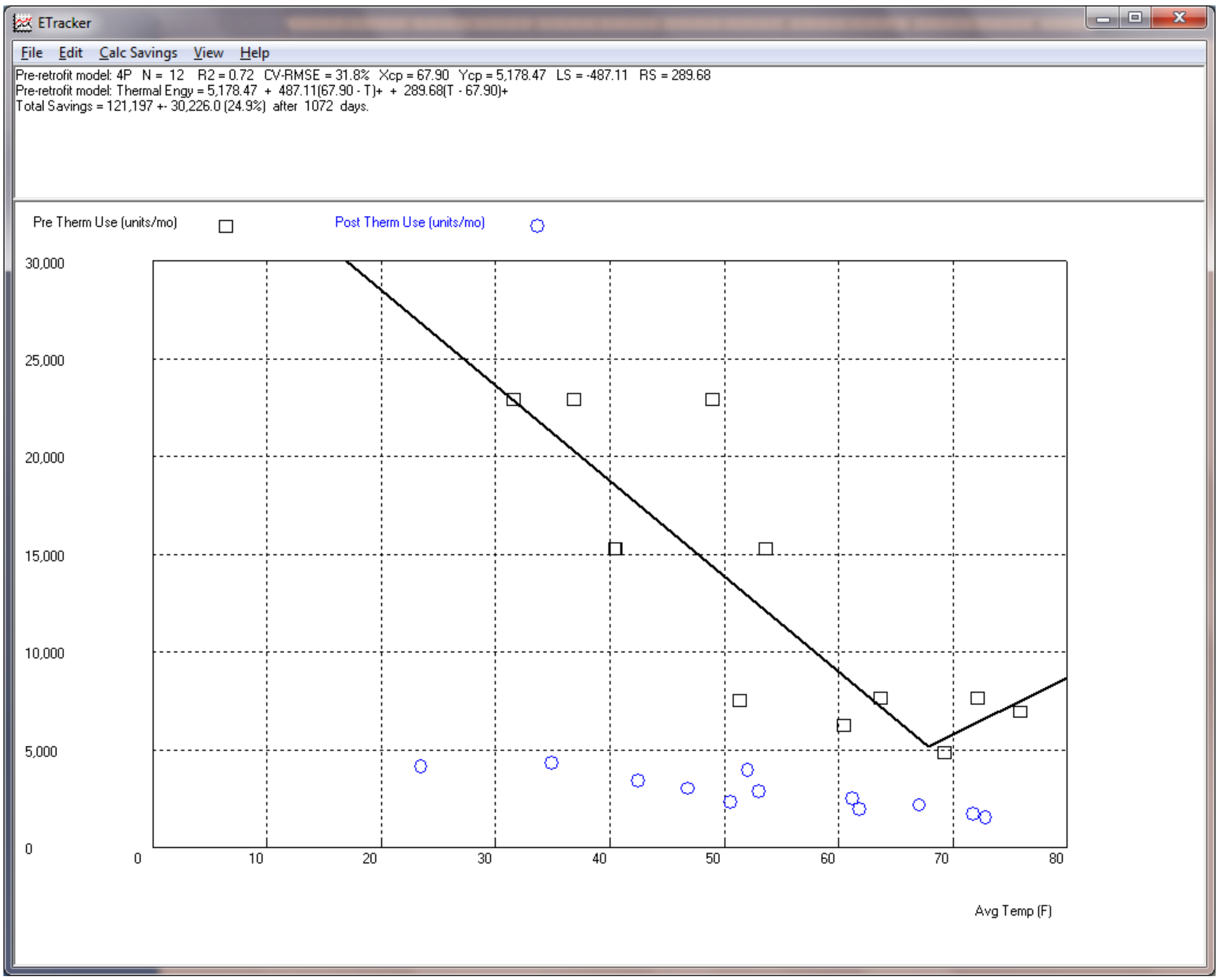
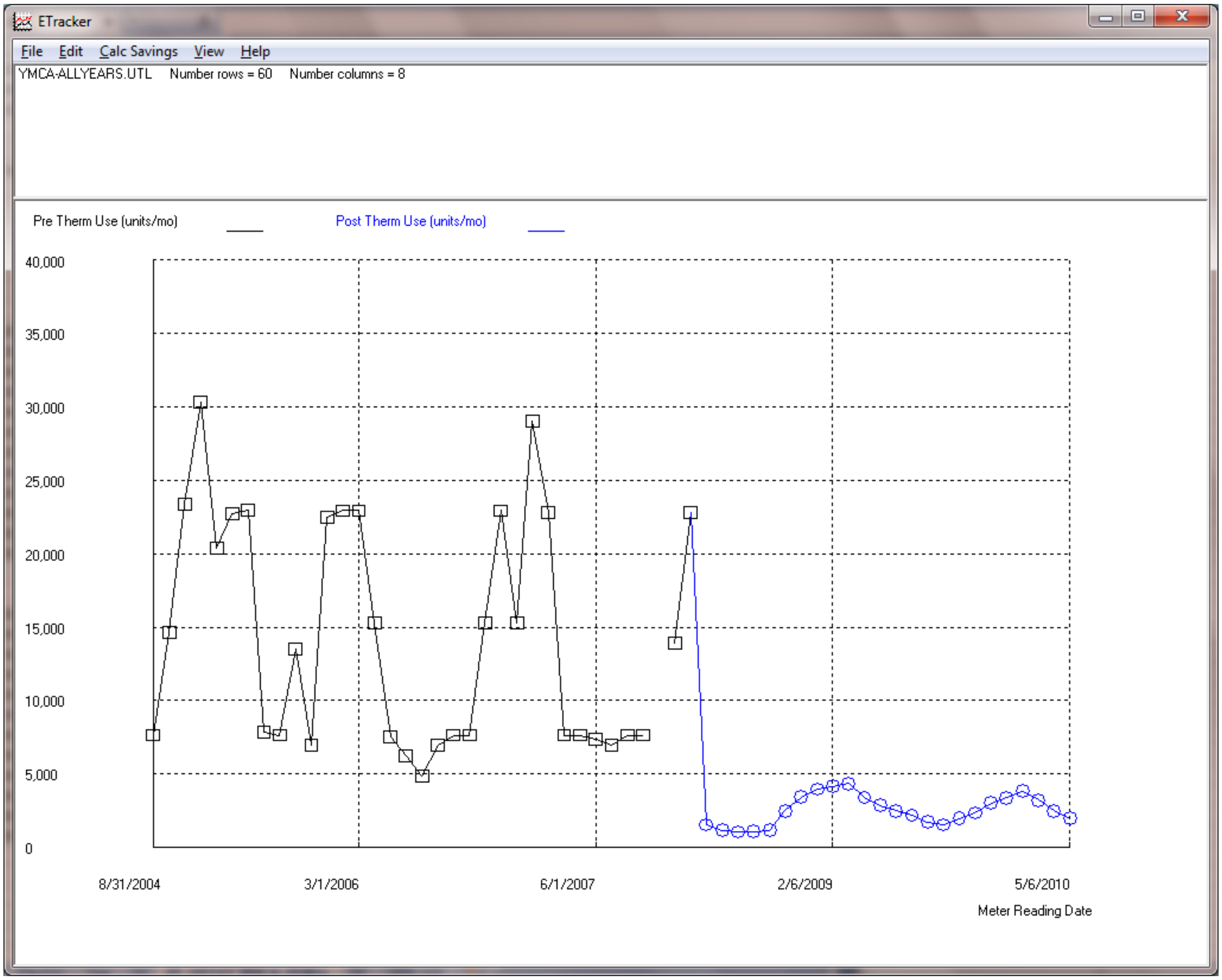


Figure 3: Billed fuel oil / natural gas use for 2004 – 2010, not weather adjusted



SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF15

March 9, 2010

SUMMARY INFORMATION

Project ID	EF15
Program Being Evaluated	Existing Facilities
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Low-rise apartment
Customer Business/Product	Apartments

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Patrick Hewlett
Report Author	Patrick Hewlett

1. PROJECT SUMMARY

This project involves the installation of hot water reset controls on individual boilers at eighteen low- or medium-rise apartment buildings in Manhattan. Hot water controls optimize circulated hot water temperature with outdoor air temperature, instead of constantly operating as if the outdoor air is at 20ºF.

1.1. Savings

Meas. ID	Measure Name		Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Install hot water temperature controls on boilers at 18 sites	Reported	5,137.1	$51,371
		Evaluated	4,556.5	n/a
		Realization Rate	88.7%	n/a

1.2. Measure Sampling

Hot water boiler controls were installed at eighteen different apartments in Manhattan. Due to the relative proximity of sites, it was possible to verify all eighteen sites, and sampling was not required for this project.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	6	$588	
On site M&V	24	$2,700	
Analysis	6	$588	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	40	$4,268	8.3%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure 1: Install Hot Water Temperature Controls on Boilers

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

The baseline for this project featured no temperature controls on any of the eighteen boilers. Heating systems were designed to heat water to a specified setpoint (180ºF) regardless of the outside air temperature. In fact, preexisting boilers produced hot water at a temperature that, under the reset scheme detailed in the proposed measure, corresponds to a 20ºF outdoor air temperature. Consequently, potential energy savings were not realized on mild days when a lower hot water temperature would have been sufficient to adequately heat the building(s).

2.1.2. Evaluation Description of Baseline

The baseline consists of the preexisting boiler at each of the eighteen sites, with no hot water temperature controls installed.

2.1.3. Seasonable Variability in Schedule and Production

Seasonal operation varies for each site. From the obtained gas bills, it is apparent that some of the boilers provide space heating only, while some provide domestic hot water (DHW) heating as well.

2.1.4. Application Description of As-Built Equipment and Operation

Hot water reset controllers were installed on the boiler at each of the eighteen apartment buildings. Each controller actuates a mixing valve that optimizes the hot water temperature needed to adequately heat the building. Control is based on outdoor air temperature. Any unused heated water is recirculated through the boiler where it remains heated and thus improves total system efficiency.

A number of affected boilers are steam boilers, and a different Heat-Timer control was installed in these five cases (see Figure 1 below). The MPC Platinum steam boiler control adjusts the duration of steam supply based on outside air conditions. Lockout logic is also present in the MPC control if the space remains adequately heated for the entirety of the cycle period.

Figure 1: Heat-Timer HWR Platinum Controls

2.1.5. Applicant Energy Savings Algorithms

The applicant's energy savings approach used 2006 gas billing data obtained from the utility as a baseline. The project measure is weather dependent, so the pre-install algorithm normalized gas usage against historical heating degree day (HDD) data obtained from NYSERDA. Average baseline weather conditions were determined from historical HDD data from 2000-2006. In this manner, the baseline was calculated in therms representative of 7 years of recent New York City weather. This normalization is characterized by use of an adjustment factor:

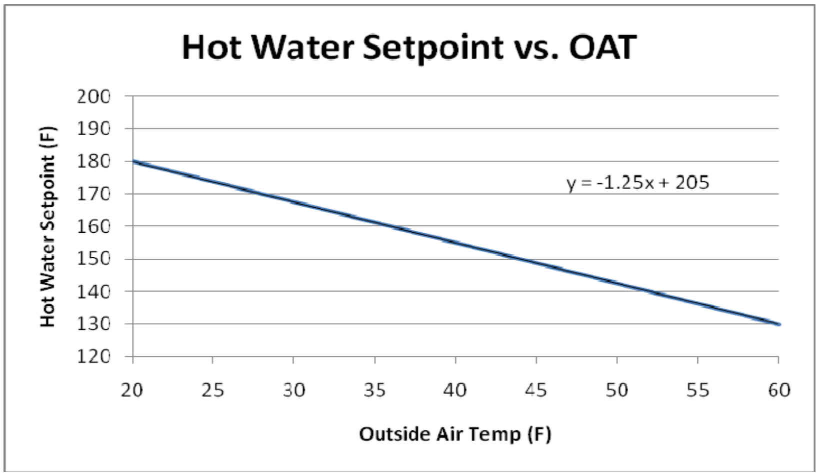
$$K = \frac{(HDD_{normal} - HDD_{actual})}{HDD_{normal}}$$

$$2006\,Therms_{base,\,normal} = 2006\,Therms_{base,\,actual} * (1 + K)$$

The proposed conditions assume the installed hot water boiler controls will control temperature in the following manner:

- Hot water is supplied at 180ºF at an outdoor air temperature of 20ºF and below.
- Hot water is supplied at 130ºF at an outdoor air temperature of 60ºF.
- For temperatures between 20ºF and 60ºF, hot water temperature is linearly interpolated between the two endpoints.
- A boiler cutoff has been set at 65ºF.

Figure 2: Expected Hot Water Boiler Control, Setpoint vs. OAT



Gas savings are assumed proportional to any hot water temperature reduction. Typical New York City weather was used to determine average outdoor air temperature—and corresponding HW supply temperature—at each hour of the day, each month. Percent savings as a function of the hot water setpoint (HWSP) temperature were calculated from:

$$\%\,Savings = \frac{(180°F - HWSP)}{180°F - 55°F}$$

The above calculation assumes an average cold-water inlet temperature of 55ºF for New York City. Additionally, a 70% savings factor was assumed in the savings calculation to account for gas use that is unaffected by supply water temperature, controls maintenance, and other unforeseen circumstances.

Savings amounted to 21% of the normalized baseline consumption, or 51,371 therms.

2.1.6. Evaluation Energy Savings Algorithms

This is a basic grade evaluation.

ERS performed billing analysis because the predicted savings exceeded 10% of the pre-retrofit energy use, no other measures were implemented at the same time, and the savings depends in part on behavioral changes that an engineering model is unlikely to reflect well.

ERS obtained monthly gas bills for each site for 2006 (pre-install) and 2009 (post-install) in order to determine *typical* pre- and post-install monthly gas usage at each site based on outside conditions. Pre-install analysis and the previous measurement and verification were not based on monthly gas consumption, rather on annual totals for each site. Use of monthly consumption data provides greater resolution and more accurate savings estimates as a result.

Historical heating degree days (HDD) is the independent variable in the linear normalization. From project documents, monthly HDD data from 2000-2008 is available, and 2009 data was extracted from NOAA historical data. An average of 2000-2009 HDD data was assumed as “typical” instead of TMY data, as only Class III TMY data from pre-1990 is available for Manhattan. ERS believes an average of 10 years of recent historical weather is more representative of “typical.” Gas bills from 2006 and 2009 were normalized against historical 2006 and 2009 HDD data, and these relations were used to extrapolate typical pre- and post-install gas consumption. Approved pre-install savings were compared with the typical annual savings determined in this manner to establish a total realization rate for the project (see Table 1 below).

Table 1: Site-by-Site Savings Comparison: ERS-Evaluated vs. Pre-Install (All Savings in therm)

Site	Evaluation			Program-Reported Savings	Realization Rate
	Normalized Pre-Install Usage	Normalized Post-Install Usage	Savings		
128 E 85th	19,329	13,711	5,618	1,535	366.0%
157 E 85th	12,509	10,049	2,460	2,584	95.2%
317 E 85th	17,065	9,434	7,631	2,308	330.7%
315 E 85th	8,328	8,755	(428)	1,227	-34.8%
434 E 84th	8,521	6,692	1,829	1,535	119.1%
225 E 85th	11,367	10,795	573	2,192	26.1%
317 E 91st	27,078	25,368	1,709	4,261	40.1%
321 E 91st	9,810	9,243	567	2,699	21.0%
312 E 92nd	21,433	14,670	6,763	2,887	234.3%
421 E 76th	6,487	5,091	1,396	2,200	63.4%
105 Lex	22,365	20,096	2,269	3,407	66.6%
151 Lex	25,677	26,506	(829)	7,181	-11.5%
104 31st	11,551	10,536	1,015	2,107	48.2%
66 2nd Ave	6,320	5,039	1,280	1,328	96.4%
334 E 74th	10,981	15,837	(4,856)	1,461	-332.4%
48 W 68th	33,553	28,526	5,027	5,843	86.0%
321 W 54th	52,849	41,398	11,451	3,486	328.5%
425 E 77th	13,541	11,452	2,089	3,130	66.7%
Total	**318,765**	**273,200**	**45,565**	**51,371**	**88.7%**

Through site visits, ERS determined that affected boilers deviate slightly from the expected control relation depicted back in Figure 2. This was determined from data pairs of hot water/steam temperature and outside air temperature recorded at each site visit. It was also confirmed that five of the sites feature steam boilers; these controls are likewise different models from those on hot water boilers. This will be addressed further in the “Uncertainties” section.

2.1.7. Data Measurement

Interview, inspect, and perform spot measurements as needed to:

- Confirm controls installation
- Confirm controls operability
- Record boiler nameplate data
- Record control system outputs: outside air temperature, system temperature, and setpoint temperature
- Determine typical outside air temperature threshold at which space heating begins/ends

- Determine any special operations schedules aside from typical HDD, if necessary

Due to the basic grade classification of this site, no equipment monitoring was performed.

2.1.8. Site Sampling Strategy

The project consists of eighteen individual apartment buildings, but due to relative proximity, sampling was not necessary. All eighteen sites were to be verified, but the superintendent at one of the sites was unreachable leading up to the site visit and not at home during the site visit period.

2.1.9. Uncertainties

Uncertainties arise due to a number of factors:

- Five of the eighteen boilers are steam boilers with different controls from the model described in the application and pre-install savings documentation.
- One of the eighteen sites was not available for verification.
- From the billing data analysis, it is apparent that several of the sites' boilers provide domestic hot water (DHW) heating in addition to space heating. This would theoretically lower the correspondence between gas consumption and heating degree days in those regression analyses.
- Variations in meter reading dates on the gas bills might cause some uncertainty in relating monthly gas consumption totals to heating degree days.
- A sample of landlord surveys did not reveal any significant increase or decrease in average occupancy rates between 2006 and 2009; nevertheless, this introduces some level of uncertainty.
- The contact reported that no other gas measures were installed during the time period between the pre- and post-retrofit periods. However, if residents installed measures or changed their behavior due to reasons other than those prompted by this measure, such as responding to changes in rates or to the overall economy, these effects are not separated in this analysis.

2.1.10. Non-Energy Impacts

There are no non-energy impacts (i.e., operations and maintenance cost or water savings) associated with this project.

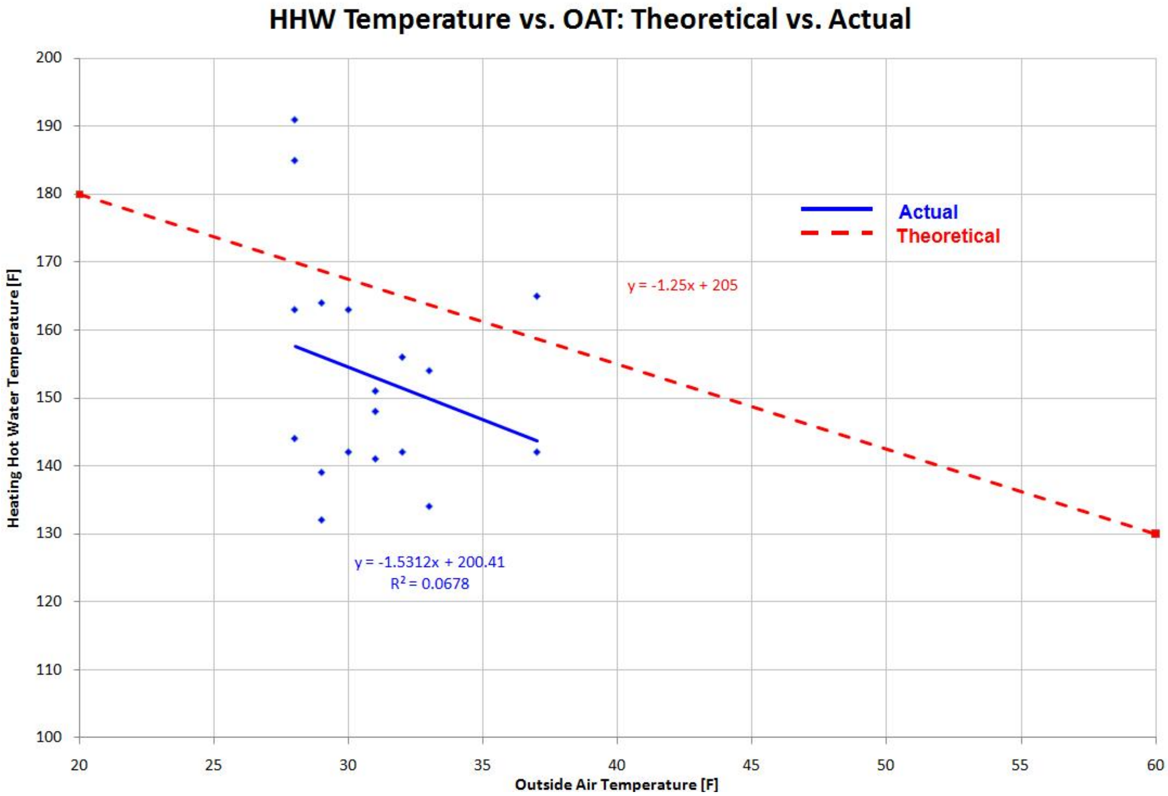
3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The evaluation savings represent 88.7% of the pre-install, predicted savings. This discrepancy is likely due to a number of factors.

- The evaluation savings were determined from a more detailed billing analysis. Monthly Con Edison gas bills for each site for 2006 (pre-install) and 2009 (post-install) were obtained. Monthly, instead of yearly, therm consumption at each address was regressed against NOAA historical heating degree days for the corresponding month and year for New York City. These relations were used to extrapolate typical pre- and post- gas consumption based on an average of the past 10 years of NOAA historical HDD data. In contrast, the pre-install estimate used a simpler normalization approach for the baseline estimation and used a formula to predict post-retrofit use as a percentage of pre-retrofit use.
- The percent savings formula assumes that gas use is proportional to the boiler setpoint temperature, relative to supply. This concept implies that the heating load is independent of any other factors. While a few loads follow this relationship (dishwasher hot water use and distribution pipe losses are examples), the majority of the heating loads are at least theoretically independent of supply temperature, e.g., building shell losses and bath and shower hot water use. This would suggest minimal savings. However as a practical matter many apartment buildings are grossly overheated at least in certain spaces, leading to higher space temperatures and open windows, and in turn higher loads. Reducing the hot water temperature can reduce this unnecessary load, and it appears to have done so significantly in many of these buildings.
- Upon visiting seventeen of the eighteen addresses, it was apparent that the boilers are deviating from the expected control depicted back in Figure 2. This deviation, which is illustrated in Figure 3 below, subsequently affects consumption savings at each apartment.

Figure 3: Actual and Theoretical Boiler Control



- Each of the verified boiler controls featured an outside air cutoff of 55ºF, instead of the pre-install 65ºF cutoff. This limits boiler use during swing seasons, thereby reducing the amount of savings opportunities, presuming pre-install controls featured a similar cutoff.
- Site-by-site deviations illustrated back in Table 1 can be attributed to theoretical vs. billing approaches between the two analyses. In the pre-install analysis, a savings percentage was applied across the board for all sites, whereas the ERS evaluation used actual billing data, pre and post, to arrive at savings. Likewise, some of the sites do not save at all, perhaps due to uncertainties in Section 2.1.10.
- Uncertainties such as domestic hot water use, variations in billing cycle, and variations in apartment vacancies could also contribute to a lower realization rate. These have been addressed in more detail in Section 2.1.10.

3.2. Deviations from Plan

This evaluation only involved verification of boiler controls at each of the eighteen sites. Aside from the single unverified site, there were no deviations from the plan.

3.3. Recommendations for Program Designers & Implementers

ERS recommends that the program application require cut sheets of any installed equipment. From program documentation, it was not clear what was installed before the site visits. This led to uncertainty about which data points would be available from the digital output.

Additionally, site-specific information on each boiler system would have helped in the M&V plan process. Specifically, the number of steam vs. hot water boilers was not known until the site visit.

3.4. Customer Alert

The lead engineer for this project provided access to each of the apartment landlords, who in turn provided access to the boiler rooms.

3.5. Contextual Data

Not applicable for verification sites.

3.6. Evaluation Dates

Assignment date	Patrick Hewlett
Plan approval date	1/28/2010
Site visit date(s)	2/10/2010-2/11/2010
Draft site report completion date	3/9/10

3.7. Checklist

Report submission package includes:
- ☑ This report
- ☑ All analysis spreadsheets

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF16

April 12, 2010

SUMMARY INFORMATION

Project ID	EF16
Program Being Evaluated	Existing Facilities (also PLR, see note in Section 3.7)
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial

Principal Site Contact	
Title	
Phone	
Email	

NYSERDA Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	.
Phone	
Email	

Lead Evaluation Engineer	Shamus Cunningham
Plan/Report Author	Shamus Cunningham

1. PROJECT SUMMARY

The facility is a 49-year-old six story 200,000 sq. ft. former hospital that has been renovated to mixed medical and commercial office space. The measure involves replacing a 1970 vintage 350-ton single-effect McQuay absorption chiller with a 300-ton TecoChill Model # CH-300X Gas powered centrifugal chiller.

1.1. Savings

Measure ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Natural Gas Centrifugal Chiller	Reported	0	0	5,762	$57,616
		Evaluated	12,354	32.1	2,283	-
		Realization Rate	-	-	40%	-

It should be noted that a review of the savings calculations was conducted by an independent third-party engineering firm. The review did not modify the reported savings figures.

1.2. Measure Sampling

Since the project involved a single measure, sampling will not be necessary to evaluate the savings.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	2112	
On site M&V	16	2327	
Analysis	20	2614	**Site Evaluation Cost / Incentive**
Report	20	2640	
Total	72	9692	9.3%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1 - Natural Gas Centrifugal Chiller

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The new 300-ton TecoChill Gas powered centrifugal chiller replaced a 1970s vintage McQuay 350-ton low pressure single effect absorber. The HVAC system supplies the building with chilled water for space conditioning from April through October. The old absorption chiller was supplied with steam by a central boiler plant that also provided the building with steam for space heating and domestic hot water throughout the year.

Table 1: Application Baseline System Specs

Unit size	350 tons
Chiller steam consumption	20 lbs/ton-hr
Estimated unit degradation	0%
Unit full load cop	0.6

The project documentation did not contain manufacturer's cut sheets for the 350-ton absorber. However, the performance specs used in the application are within the range of standard full load COP values of single effect absorption chillers.

2.1.2. Evaluation Description of Baseline

The baseline for this measure is similar to that described in the previous section. The absorption chiller was described as "at the end of its useful life and in need of replacement." Because this 1970s unit was at the end of its service life and replacement with similar type of equipment is a viable option, the evaluators chose to use the minimum performance specifications for new single-effect steam-driven absorption units as described in the 2007 New York Conservation Construction Code. This code specifies a minimum full load COP of 0.7 for water cooled single effect absorption chillers, but does not specify a minimum IPLV for these systems. As such, the evaluators performed a survey of current equipment that meets the minimum NYCCC requirements to determine the appropriate IPLV.

Table 2: Evaluation Baseline System Specs

Unit Size	300 tons
Unit Full Load COP	0.700
Unit IPLV COP	0.687
Steam boiler efficiency	70%

Figure 1: Standard Single-Effect Part-Load Efficiency Curves[1]

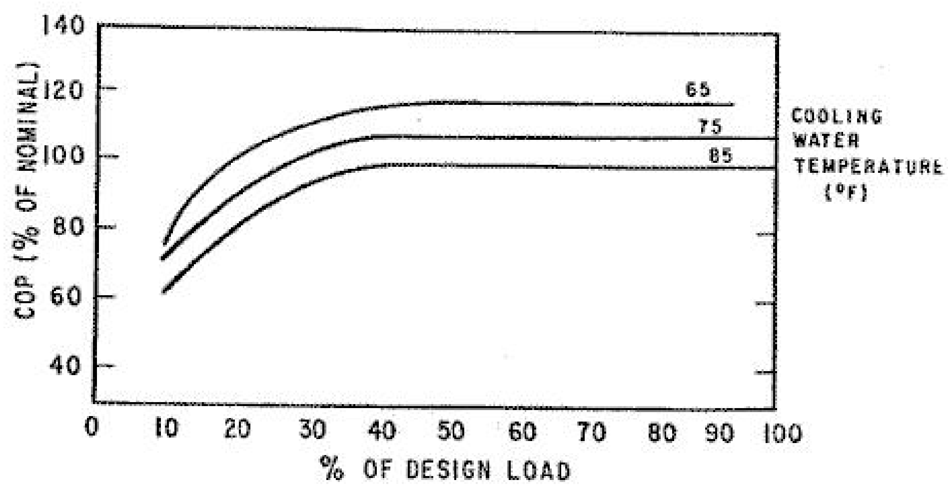


Fig. 2.8 Percent of Nominal COP Vs the Percent of Full Design Load for Various Cooling-Tower Water Temperatures.[4]

2.1.3. Seasonable Variability in Schedule and Production

According to the application, building cooling takes place between April and October with peak cooling loads between June and September. Because building chiller logs were unavailable on-site, a correlation of the cooling profile to the standard TMY3 weather file was not able to be performed.

2.1.4. Application Description of As-Built Equipment and Operation

The McQuay 350-ton absorption chiller was replaced with a gas-powered TecoChill 300-ton CH-300x. The new chiller is a high performance centrifugal chiller directly powered by a natural gas-fed internal combustion engine. The chiller supplies 40°F to 60°F water to the site during the cooling season. This chiller is supplied directly with natural gas. The chiller also contains its own meter, which does not supply any other equipment in the facility.

[1] Technology Evaluation of Central Cooling – absorptive chillers, JE Christian - Oak Ridge National Laboratory

Table 3: Application As-Built System Specs

Unit size	300 tons
Chiller full load COP	1.7
Chiller IPLV COP	2.6
Estimated unit degradation	0%

2.1.5. Applicant Energy Savings Algorithms

The savings were calculated as follows:

A billing analysis was conducted on the boiler plant natural gas and #2 oil accounts. The natural gas usage was converted to Btus using a conversion factor of 100,000 Btu/therm and the #2 oil usage was converted to Btus using a conversion factor of 140,000 Btu/gallon. The total Btu usage of the boiler plant for the months of May-October was assumed to supply the chiller plant. The boiler plant Btus were converted to cooling load tons through the conversion factors of 70% boiler efficiency, 1024 Btu/lbs steam, and 20lbs-steam/ton cooling (.6 COP). The monthly analysis concluded that the building's chiller was currently being used for 317,800 ton-hrs /year or 908 full-load hrs/year.

This billing analysis was supported by chiller logs that showed peak cooling rates of 315-350 tons between the hours of 12 PM and 5 PM.

Using the annual ton-hrs of the old chiller the new projected gas usage of the installed system was determined using the nameplate COP of the new system as compared to the old chiller COP. In addition, because the new system does not utilize the boiler plant, savings were seen because the boiler plant efficiency did not have to be included in the new system energy usage calculations. Annual savings were determined by subtracting the annual gas usage difference.

2.1.6. Evaluation Energy Savings Algorithms

The savings were calculated as follows:

A billing analysis was conducted on the dedicated chiller gas account. Because of building renovations and changes in HVAC system since the old system was replaced, the evaluators chose to use the new chiller gas bills to determine the annual cooling load hours.

The monthly chiller loads were determined by using the new chiller's Integrated Part Load Value Coefficient of Performance, as quoted in the TecoChill CH-300x performance data. The IPLV accounts for the part-load efficiency of the chiller system, which is significantly different from the full-load performance for the installed chiller due to the centrifugal compressor design.

Table 4: Chiller Specs Used in Analysis

New Chiller Specs	
Full Load COP	1.7
IPLV COP	2.6

Old Chiller Specs	
Full Load COP	0.7
IPLV	0.6874
Boiler Efficiency	70%

Table 5: Monthly Savings Table

From Date	To Date	Billed Gas Usage (Therm)	Chiller Load (ton-hrs)	Baseline Chiller Gas Usage (Therms)	Savings (Therms)
10/6/2009	11/4/2009	-	-	-	-
9/4/2009	10/6/2009	637	13,802	3,380	2,743
8/6/2009	9/4/2009	1,576	34,147	8,362	6,786
7/8/2009	8/6/2009	1,558	33,757	8,267	6,709
6/8/2009	7/8/2009	1,083	23,465	5,747	4,664
5/7/2009	6/8/2009	258	5,590	1,369	1,111
4/8/2009	5/7/2009	72	1,560	382	310
3/10/2009	4/8/2009	-	-	-	-

Savings Algorithm

The monthly chiller loads for the 2009 chiller usage was converted to gas usage for the baseline system using the following equation.

$$Gas\ Usage\ (Therms) = \frac{12{,}000\left(\frac{btu}{ton-hr\ cooling}\right) * Cooling\ load\ (Ton-hrs)}{Chiller\ IPLV * 100{,}000\ \left(\frac{btu}{Therm}\right)}$$

Because the evaluation period was in the winter, the system was not functional as it had been drained of its working fluids for the season. As such, the performance of the installed system is assumed to be the same nameplate performance listed in the original application.

Using the IPLV instead of the full load COP to determine the savings from this measure increased the performance difference between the single effect absorption chiller and the internal combustion gas powered chiller. However, because the total chiller load was overestimated in the original analysis the total evaluated project savings was only 35% of the projected savings.

Table 6: Realization Rates

Year	Chiller Load Realization Rate	Energy Savings Realization Rate
2009	35%	40%

2.1.7. Data Measurement Method

Equipment monitored	Chiller
Parameter measured	Performance data, operating hours
Measurement equipment	Interviews with the site staff & manufacturer, chiller log records
Observation frequency	N/A
Metering duration	N/A
Accuracy	N/A

2.1.8. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.9. Uncertainties

Based on information available in the project documentation, the analysis will be conducted based on monthly cooling loads. The monthly numbers will be used to calculate the average yearly values.

Overall expected engineering accuracy including metering accuracy and uncertainties: 10%

2.1.10. Non-Energy Impacts

The increase in efficiency from the single-effect absorption chiller to the gas-powered chiller has reduced the amount of heat that is rejected to the system’s cooling tower. The reduction in cooling tower thermal load results in decreased electrical load on the cooling tower fan and condenser water pump as well as reduced water treatment and consumption due to vaporization. Direct fire chillers produce 40%-50% less thermal load on cooling towers than single-effect absorption units.

Electrical Savings

The reduced heat that is processed by the cooling tower results in lower electrical loads. Table 7 illustrates the standard normalized electrical consumption of condenser water pump and cooling tower fans for different chiller types.

Table 7: Cooling Tower Fans and Condenser Water Pump Capacities[2]

#	Chiller type	Cooling Tower Fans	Condenser Water Pump*	Total
		kW/ton	kW/ton	kW/ton
1	Single-stage steam absorption chiller	0.138	0.110	0.248
2	Two-stage absorption chiller	0.113	0.096	0.209
3	Natural-gas engine chiller	0.087	0.054	0.141
* These numbers are based on efficiencies of pump of 0.7 and motor – 0.9.				

Table 8: Electrical Savings

Year	kW Savings	Annual Full Load Chiller Hrs	Average Electrical Rate ($/kWh)	Annual Savings ($)
2009	32.1	374.4	$0.13	$1,605.99

Water Savings

The system installation also resulted in reduced water consumption as the total amount of water that was vaporized to cool the system was reduced due to the much smaller thermal loads. Typical water consumption data was found to determine the magnitude of savings.

Table 9: Cooling Tower Water Savings

Year	Water Savings (gallons/ton-hr)	Annual Chiller Load (ton-hrs)	Average Water Treatment Cost	Annual Savings ($)
2009	3.7	112,320	$4 per 1000 gallons	$1,662.34 [3]

[2] Cooling System Alternatives, http://tristate.apogee.net/cool/cfsc.asp, last visit on May 19, 2010

[3] Cooling System Alternatives, http://tristate.apogee.net/cool/cfsc.asp, last visit on May 19, 2010

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The monthly cooling loads in our 2009-based billing analysis were significantly lower than the values predicted using the 2006 billing analysis included in the original application. This could be due to three factors:

1. The original application assumed that all of the steam generated in the boiler plant was used by the chiller and did not account for any usage by domestic hot water or space heating, which was served by the same boiler plant during the summer. This likely resulted in overestimation of chiller energy.
2. The performance of absorption chillers has been found to degrade approximately .5% per year of service. As such the actual COP of the original system used to calculate the chiller system ton-hrs could have been as low as 0.51. This lower COP would have reduced the calculated chiller plant's annual ton-hrs. While this change would have increased savings if this was a retrofit project, it had a detrimental effect on savings as a new construction project.
3. The renovation of the property, which included the installation of an entirely new HVAC distribution system included replacing constant volume AHUs with variable volume AHUs, could have resulted in a significantly lower annual cooling load. This upgraded AHU system was not included as part of this measure but may have contributed to lower cooling loads on the chiller.

3.2. Deviations from M&V Plan

Because the full EMS system with trended data that was described in the original application was not installed on-site, hourly data that could have been trended against outside air temperatures was not available for this analysis. As a result the reviewers had to use a post-retrofit monthly billing analysis strategy.

3.3. Recommendations for Program Designers & Implementers

The project received $57,616 in gas funding under the ECIPP program (PON 1101, PO #10347) because the installed chiller reported saving 57,616 therms/year compared to a less efficient 300-ton absorption chiller. This is why the chiller is in the gas evaluation population. NYSERDA received the ECIPP application in 6/07 and approved it after installation in 1/08.

Evaluators discovered that this same chiller project also received a $109,800 PLRP (PON 1097, PO #8647) incentive for 183 kW demand reduction and 234,614 kWh/yr energy savings from ConEd SWP/SBC3 Split funding, on the basis that installing the efficient gas chiller avoided purchase of a 300-ton electric chiller. NYSERDA received the PLRP application in 2/07 and approved it after installation in 10/07.[4]

[4] Disclosure: ERS worked as a TA reviewer for NYSERDA on this PLR application.

There are no “cross-program notes” in the Portal under either the ECIPP or PLR project listings. Evaluators are certain only one new chiller was installed. Indeed the same invoice was used for both applications.

One could contend that an exception to the single-measure rule is warranted because the PLR savings is due to the portion of the measure associated with staying with gas via a new (theoretical) single-effect absorber instead of switching to electricity, and that the CIPP gas savings is due to a portion of the measure associated with the efficiency upgrade from the new theoretical single-effect absorber to a new turbine. However, the PLR-reported results then would need to have reflected the negative gas impact single-effect absorber in addition to the electric savings for this fuel switching measure. Evaluators did not find evidence in the portal that this was done.

Presuming the above is correct, the impact is not being reported correctly. A separate memorandum addresses the process-related ramifications of this issue.[5]

Recommended actions:

1. If the developer understood this policy to be acceptable once, it is possible he applied the same logic multiple times. The developer has twenty-two PLR projects listed with the same site name as CIPP projects. Most are likely to have technologically unrelated projects but it would be prudent for program staff to review and affirm that none of these projects received double funding and double savings without the appropriate negative impact as this one did.
2. Further, if other developers were granted similar exceptions there should be a more systematic examination regarding funding and appropriate negative impact accounting that NYSERDA should identify and correct.

Evaluators have *not* systematically weighted this error as a “representative” error in the sample, under the presumption that this was a unique error and because the potential adjustment goes well beyond the scope of gas evaluation and could affect electric-only reported savings for which it is impossible and inappropriate to adjust in this study.

To appropriately represent impact NYSERDA should either:

1. Remove reported the PLR savings--Use this ECIPP site evaluation as written and remove the PLR savings from the Portal
2. Remove the reported ECIPP savings--Remove all ECIPP savings from the portal
3. Allow the exception and report both programs’ savings but adjust the reported PLR savings—Use this ECIPP site evaluation as written, retain the PLR electric savings as reported, and adjust the PLR gas impact from 0 to a negative savings of 7,994 MMBtu/year (the ECIPP *ex ante* theoretical existing conditions energy use).

[5] Refer to ERS memorandum from J. Maxwell to T. DeSimone of 5-10-2010.

3.4. Customer Alert

All site contacts were conducted through LC Associates, the site’s ESCO. LC Associates was extremely reluctant to allow the evaluators to contact the customer directly and insisted that all contact go through them.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	200,000 sq ft
Building predominant year of construction	1957

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/21/2010
Site visit date(s)	3/2/2010
Draft site report completion date	4/12/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF17

April 15, 2010

SUMMARY INFORMATION

Project ID	EF17		
Program Being Evaluated	Existing Facilities		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Commercial		
Customer Business/Product			

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Shamus Cunningham
ReportAuthor	Shamus Cunningham

1. PROJECT SUMMARY

The facility is a 291-bed acute-care facility. The measure involves replacing a 527-ton double effect Trane absorption chiller with a 750-ton double effect absorption chiller as part of a renovation in order to meet greater anticipated chilled water demand.

1.1. Savings

Measure ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Absorption chiller	Reported	0	0	6,031.6	$90,474
		Evaluated	0	0	6,670.1	-
		Realization Rate	-	-	111%	-

It should be noted that a review of the savings calculations was conducted by an independent third party engineering firm. The review did not modify the reported savings figures.

1.2. Measure Sampling

Since the project involved a single measure sampling, it will not be necessary to evaluate the savings.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	$2,112	
On site M&V	16	$2,327	
Analysis	20	$2,614	**Site Evaluation Cost / Incentive**
Report	20	$2,640	
Total	72	$9,692	9.3%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The new 750 ton Trane absorption chiller replaces a 1980s vintage Trane ABTD 527 ton high pressure double effect absorber. The absorption chiller operates April through October and is supplied with steam by two (2) central high pressure boilers, which also provide steam for winter heating, domestic hot water, sterilization, and other hospital purposes.

Unit Size	527 tons
Chiller Steam Consumption	12.2 lbs/ton-hr
Estimated Unit Degradation	10%
Unit COP	0.87

The project documentation contained manufacturer's cut sheet for the original 527 ton absorber which verified the performance specs used in the application's analysis.

2.1.2. Evaluation Description of Baseline

The evaluator interviewed the site contact, who reported that the pre-existing boiler was in good working condition and could have continued in service for the foreseeable future. While facilities staff bought a larger chiller in anticipation of future load and load has increased, analysis revealed that the current cooling load could have been met over 95% of the time with the old unit's degraded capacity of 474 tons. Thus the measure is "replacement of working equipment" for the entire cooling load and baseline efficiency is pre-existing chiller efficiency.

The baseline for this measure is considered to be the same as described in previous section.

During the site visit the site contact confirmed the make and model of the previous system to be the same Trane unit described in the application. There was no ASHRAE efficiency standard for double effect absorption chillers in effect at the time of chiller installation. ASHRAE 90.1 1999 is the first version in which the standard specifies a minimum efficiency for double effect absorption chillers. It states a minimum COP of 0.95 for double effect absorption chillers, which is equivalent to 12.8 lbs/hr steam/ton. The removed chiller was at least 20 years old. Assuming a degradation rate of .5% per year, the efficiency had degraded by 10% by the time of replacement and it operated with a 0.855 COP and 14.2 lb/hr steam/ton.

Evaluators determined baseline cooling load through post-retrofit chiller load analysis.

2.1.3. Seasonable Variability in Schedule and Production

According to the application, building cooling takes place between April and October with peak cooling loads between June and September. Building chiller logs were correlated to outside air temperatures in order to obtain a building cooling profile. This correlation was used to develop a cooling profile for the standard TMY3 weather file.

2.1.4. Application Description of As-Built Equipment and Operation

The Trane 527 Ton absorption chiller was replaced with a single Trane 750 Ton ABTF-750. The new chiller is a high performance high pressure/two stage absorption chiller. The chiller supplies 40F to 60F water to the site during the cooling season. This chiller is supplied with steam by two 115 psig boilers which also supply steam for heating, domestic hot water as well as steam for hotel processes.

Unit Size	527 tons
Chiller Steam Consumption	9.88 lbs/ton-hr
Estimated Unit Degradation	0%
Nameplate Unit COP	1.19

2.1.5. Measure Life

An evaluation of the measure life in not part of the scope of this project and will be assumed to be the same as described in the project documentation.

2.1.6. Applicant Energy Savings Algorithms

The savings were calculated as follows:

A billing analysis was conducted on the gas account that serves the boiler plant for the calendar year of 2006. The base load steam use (when boilers were not being used for either heating or cooling) was determined from steam logs in the shoulder season to be approximately 2000 lbs/hr. This value was converted to natural gas therms, using an assumed efficiency of 70% for the boilers. This value was subtracted from the monthly bills and used to determine the monthly gas usage of just the heating and cooling of the building.

The remaining natural gas usage was then assigned to heating or cooling through a weather analysis of the ratio of cooling degree days (CDD) to heating degree days (HDD) in a given month. It was unclear in the program documentation what the assumed building temperature balance point was to calculate the ratio of CDD to HDD. This method also assumes that the same amount of steam is used per CDD and HDD, which is an assumption that is not justified in the included program documentation.

From the monthly cooling gas usage and the nameplate performance of the old chiller system, the monthly ton-hrs for the building in 2006 was determined. Using the monthly ton-hrs of the old chiller the new projected gas usage of the installed system was determined using the nameplate COP of the new system. Annual savings were determined by subtracting the monthly gas usage difference.

2.1.7. Evaluation Energy Savings Algorithms

Chiller Log Analysis

Since a central Energy Management System was not in use at the site, high resolution trended data was not available for the chiller’s operation. The site’s maintenance department did keep chiller logs that recorded the instantaneous performance of the system for the summer of 2009 (see Figure 1). The logs were taken at 140 points during the summer. Recorded data included chilled water inlet and outlet temperature as well as inlet and outlet pressure of the chilled water loop.

The chilled water flow rate was determined using the chilled water pressure drop from the chiller logs and the chiller spec sheets (see Figure 2). The chiller averaged 2300 gpm throughout the year. With the chilled water flow rate and the temperature drop across the absorption chiller, the total cooling tons were established for all 140 points recorded in the chiller logs.

Figure 1: Sample Chiller Log

North Mech al Room

Lawrence Ho Center

Trane Absorption Unit y Log
North and East Wings

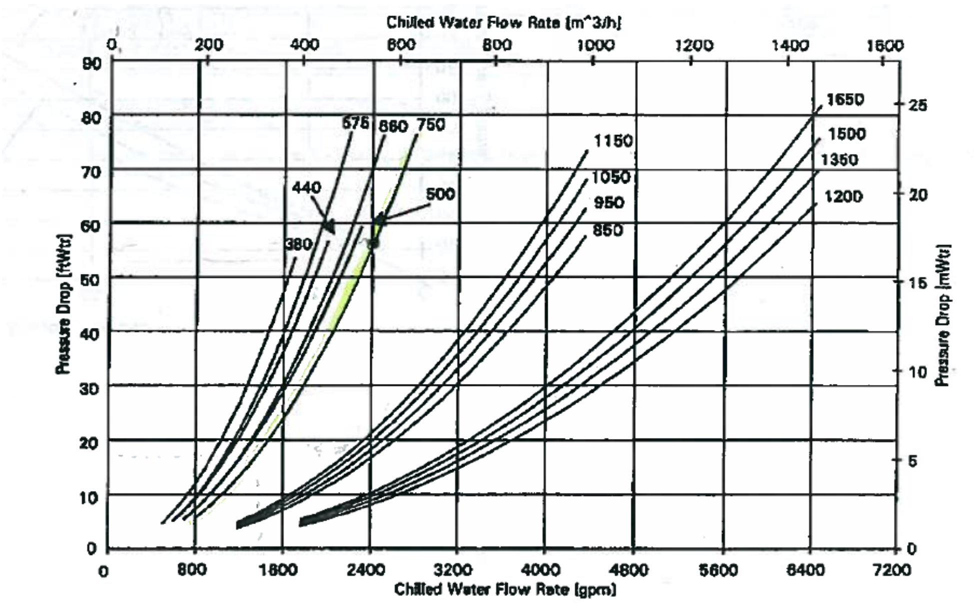
9-29-09

Date: 9/29/09

	Initials: TOB	Initials: HS	Initials:	Initials:	Initials:	Initials:	
	Time: 00:45	Time: 915	Time:	Time:	Time:	Time:	Time:
Sol Temp Lvg HTG	294 F	303 F	F	F	F	F	F
Interstate Vapor Temp	177. F	181 F	F	F	F	F	F
Sol Temp Ent Level Control	211 F	216 F	F	F	F	F	F
Mixed Sol Temp Ent LTHX	194 F	199 F	F	F	F	F	F
Sol Temp Ent HTG	260 F	270 F	F	F	F	F	F
Interstate Vapor Pressure	-6.9 psig	6-5 psig	psig	psig	psig	psig	psig
HTG Lvg Sol Conc	63.76 %	64.26 %	%	%	%	%	%
LTG Lvg Sol Conc	61.93 %	62.75 %	%	%	%	%	%
SDR Temperature	177 F	178 F	F	F	F	F	F
SDR Trip Temperature	195 F	199 F	F	F	F	F	F
Sol Temp Lvg LTG	185 F	183 F	F	F	F	F	F
Sat Cond Refgt Temp	87.5 F	88 F	F	F	F	F	F
Absorber Ent Conc	63.84 %	63.44 %	%	%	%	%	%
LiBr Crystallization Margin	13.7 F	16 F	F	F	F	F	F
Sol Temp Ent Abs	122 F	120 F	F	F	F	F	F
Abs Spray Temp	120.3 F	121 F	F	F	F	F	F
Sol Temp Lvg Abs	105 F	106 F	F	F	F	F	F
Sol Temp Ent LTG	180.9 F	179 F	F	F	F	F	F
Sat Evap Refgt Temp	4011 F	40 F	F	F	F	F	F
Evap Lvg Temp	39.3 F	39 F	F	F	F	F	F
Evap Ent Temp	43.4 F	42 F	F	F	F	F	F
Abs Ent Temp	84.5 F	83 F	F	F	F	F	F
Abs Lvg Temp	88.7 F	87 F	F	F	F	F	F
Cond Lvg Temp	87.3 F	86 F	F	F	F	F	F
Supply Steam	114 psig	110 psig	psig	psig	psig	psig	psig
Generator	78.3 psig	77 psig	psig	psig	psig	psig	psig
Entering Steam	308 F	303 F	F	F	F	F	F
Condensate Leaving	185 F	183 F	F	F	F	F	F
Energy Valve Pos	25 F	9 F	F	F	F	F	F
Sol PMP AFD Cmnd	14 F	23 F	F	F	F	F	F
Energy Input Cond	27 F	23 F	F	F	F	F	F
Condensation Water Suction	34 PSIG	32 PSIG	PSIG	PSIG	PSIG	PSIG	PSIG
Condensation Discharge	80 PSIG	81 PSIG	PSIG	PSIG	PSIG	PSIG	PSIG
Chilled Water Suction	63 PSIG	61 PSIG	PSIG	PSIG	PSIG	PSIG	PSIG
Chilled Water Discharge	84 PSIG	83 PSIG	PSIG	PSIG	PSIG	PSIG	PSIG

Comments:

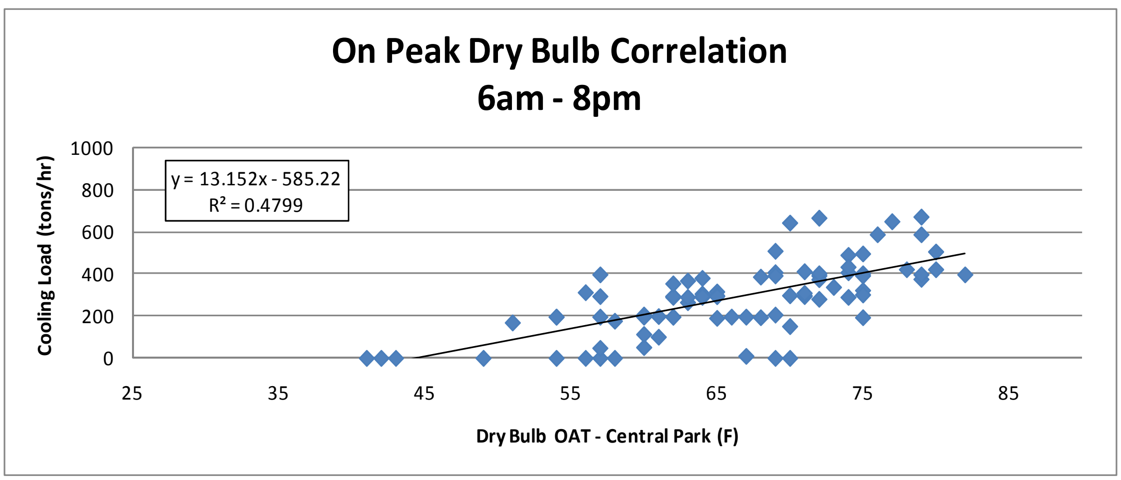
Figure 2: Chiller Pressure Drop to Chilled Water Flow Spec Sheet



Weather-based Load Correlation

For all 140 points in the chiller log the OAT dry-bulb and wet-bulb temperatures were established at the recorded time on the log using NOAA data for Central Park, NYC. The chiller loads were then split up into on-peak and off-peak loads. On-peak hours were defined as 6 AM to 8 PM as described by the site contact. Data for the on- and off-peak building cooling loads were then plotted against the OAT (see Figure 3). The chiller loads showed a distinct step function quality because the high flow rates of the system led to small temperature drops, which were only recorded in 1 degree increments.

Figure 3: On-Peak Chiller Load vs. OAT



Estimating Annual Chiller Loads Using TMY3 Weather Data

The annual chiller loads for the TMY3 weather file were established using the correlations seen in Figure 3 as well as site specific operating procedures the site contacts informed us of. The building balance point is about 55°F.

Boiler Efficiency

Combustion tests were performed on the two 18,000 lbs/hr Nebraska Boiler units onsite to determine the relationship between chiller steam savings and gas savings. Both boilers were well maintained and in full operation while combustion tests were performed. Table 1 summarizes the testing results. The application used an assumed net boiler efficiency of 70%; this was changed to 80.0% in our analysis to reflect the combustion tests results.

Table 1: Combustion Analyiser Results

	Efficiency (%)	Ex Air (%)	O2 (%)	CO2 (%)	Capacity (lbs/hr)
Boiler 1	82.4%	57.0%	7.6%	7.5%	18,000
Boiler 2	77.5%	91.0%	10.0%	6.2%	18,000
Average	80.0%	74.0%	8.8%	6.9%	18,000

Savings Algorithm

The monthly chiller loads for the TMY3 weather file, which were calculated using the chiller load correlation, were converted to steam and gas usage for the baseline and installed systems using the following equations:

$$Steam\ Usage\ (lbs) = \frac{12{,}000\left(\frac{btu}{ton-hr\ cooling}\right) * Cooling\ Load\ (Ton-hrs)}{1032\left(\frac{Btu}{lbs\ steam}\right) * Chiller\ COP}$$

$$Gas\ Usage\ (therms) = \frac{Steam\ Usage\ (lbs) * 1032\left(\frac{Btu}{lbs}\right)}{Boiler\ Efficiency\ (\%)}$$

Because the evaluation period was in the winter, the system was not functional as it had been drained of its working fluids for the season. As such, the performance of the installed system is assumed to be the same nameplate performance listed in the original application.

Table 2: TMY3 Monthly Savings Calculations

-	April	May	June	July	August	September	October	Total
TMY3 Chiller Loads								
Total Ton-hrs	53,814	165,952	276,530	336,059	304,285	240,113	84,814	1,461,567
Max Tons	572	664	586	638	624	520	413	664
New Chiller System								
Steam for Cooling (lbs)	525,836	1,621,574	2,702,073	3,283,752	2,973,275	2,346,227	828,744	14,281,482
Gas Usage (Therms)	6,788	20,931	34,879	42,387	38,379	30,285	10,697	184,346
Baseline Chiller								
Steam for Cooling (lbs)	722,185	2,227,074	3,711,034	4,509,915	4,083,505	3,222,314	1,138,200	19,614,227
Gas Usage (Therms)	9,322	28,747	47,902	58,214	52,710	41,594	14,692	253,182
Savings (Therms)	2,534	7,816	13,024	15,827	14,331	11,309	3,994	68,835

2.1.8. Data Measurement Method

Equipment monitored	Boilers	Chiller
Parameter measured	Combustion efficiency	Performance data, operating hours
Measurement equipment	Combustion analyzer	Interviews with the site staff & manufacturer, Chiller Log Records
Observation frequency	Spot measurement	N/A
Metering duration	N/A	N/A
Accuracy	± 1 % reading	N/A

2.1.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation, the analysis will be conducted based on monthly cooling loads. The monthly numbers will be used to calculate the average yearly values.

Overall expected engineering accuracy including metering accuracy and uncertainties: 10%

2.1.11. Non-Energy Impacts

There were no non-energy impacts (i.e., operations and maintenance cost or water savings) associated with this project.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The monthly cooling loads in our TMY3 weather and regression-based analysis were slightly higher than the values predicted using the cooling degree day / heating degree day logic contained in the original application. This more than offset the 12.5% decrease in savings associated with the higher measured boiler efficiency.

3.2. Deviations from M&V Plan

There were no major deviations from the submitted M&V plan.

3.3. Recommendations for Program Designers & Implementers

None

3.4. Customer Alert

None. The site contact was extremely helpful and more than willing to discuss energy efficiency opportunities.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	500,000 sq ft
Building predominant year of construction	

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/21/2010
Site visit date(s)	1/26/2010
Draft site report completion date	3/20/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID [1]	EF18	
Site Name	EF18	
NYSERDA Program Component		
Nexant Project Reviewer	Angela Patnode	
Nexant Project Inspector	Angela Patnode and Salil Gogte	
Inspection Date and Time	3/12/2007 @ 7:30 AM	
Measure Description [3]	**Pipe Insulation**	
	NYSERDA	**Nexant**
Insulation Manufacturer #1 [4]	Johns Manville	Johns Manville
Insulation Brand #1	Micro-Lok	Micro-Lok
Insulation Manufacturer #2	Knauf Insulation	Knauf Insulation
Insulation Type #2	1000 Degrees Pipe	1000 Degrees Pipe
Total Insulation Length, Feet [5]	14,030	14,030
Pipe Diameter, Inches	4	Varies from 4" max to 1.5" min
Insulation Thickness, Inches		2" (on 4" pipe) to 0.5" (on 1.5" pipe)
Hours of Operation, Winter	4380	5110
Hours of Operation, Summer	0	3650
Avg Fluid Temperature, Winter, F		139
Ambient Temperature, Winter, F		71.5
Avg Fluid Temperature, Summer, F		43
Ambient Temperature, Summer, F		75
Average Thermal Conductivity from 75 - 100 F, Btu-in/hr-ft2-F	0.235	0.235
Heat Loss from System with Bare Pipe, Winter, kBtu/hr [6]		1,282.5
Heat Loss from System with Insulated Pipe, Winter, kBtu/hr		193.8
Heat Gain to System with Bare Pipe, Summer, kBtu/hr		493.2
Heat Gain to System with Insulated Pipe, Summer, kBtu/hr		91.1
Heat Loss Reduction, Winter, MMBtu		5,563.4
MMBtu		1,467.7
Estimated Boiler Efficiency		0.8
Estimated Chiller COP		1.6
Baseline Energy, MMBtu		
Proposed Energy, MMbtu		
MMBtu Gas Savings	9694.73	7871.5
Gross Realization Rate[7]		81.2%

File Notes	1. - 2. Project file shows square footage of 13,779 ft2, which seems too small; site contact reported total square footage of about 140,000 ft2
Inspection Notes	3. Project is insulation on 2-pipe hot/chilled water distribution system for fan-coil unit heating/cooling in a new construction project. Chilled water is produced by natural gas chiller; hot water may be produced by natural gas heat pump, but site contact reports the loop was solely heated by a backup natural gas water heater during past winter heating season. Project was originally bid without insulation. 4. Manufacturers and models could not be confirmed on site; observed yellow fiberglass insulation with white outer coating, which matches descriptions shown in product literature in project file. Manufacturer literature was used to obtain thermal conductivity of insulation 5. Actual installed length was not physically verified, due to the size of the project and majority of insulation being behind finished walls; given the overall building size confirmed by the site contact (140,000 ft2) and amount of insulation observed during the inspection, the reported insulated length is reasonable 6. All heat loss calculations obtained from 3E Plus software using process temperatures, ambient temperatures, total length, pipe diameters, thermal conductivity, and insulation thicknesses disclosed above. Assume distribution of 20% of total length at 4" diameter, 60% of total length at 2.5" diameter, and 20% of total length at 1.5" diameter 7. The NYSERDA stipulated value was derived based on a 4" average diameter pipe; the majority of piping insulated for this particular project was observed in the 1.5" – 2.5" diameter range. The piping insulated for this project is in use all year (for either heating or cooling), twice the 4380 hrs/yr assumed for the stipulated savings. The combined effect of these discrepancies produces the adjustment in the savings shown

ERS Review Notes	Note #1 removed to genericize report.

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	EF19
Site Name	EF19
NYSERDA Program Component	EF19
Nexant Project Reviewer	Victor Narkaj
Nexant Project Inspector	Victor Narkaj
Inspection Date and Time	2/26/2009

Measure Description	**Piping Insulation**	
	NYSERDA	**Nexant**
Baseline		Bare pipe
Total Gas Savings (MMBtu)	11,263	0
Electric Impacts (kWh)		824,766
Realization Rate	0%	

Inspection Notes / Findings	1. The insulated piping in question for this project is the associated piping for the ground source heat pump heating & cooling system. The building is a 10 story apartment building, which is new construction. 2. The heating and cooling of the apartment units at this site is accomplished by ground source heat pumps. There are not other sources of heating or cooling equipment in the building. The hallways and reception area ventilation is accomplished by a dual capability (heating/cooling) Carrier rooftop unit, which is not part of the scope of this project. This Carrier unit consumes natural gas to provide its heating. 3. The natural gas consumption for this building is only through the Carrier rooftop unit, and an additional line that may be used if the retail space on the first floor chooses to use it. Currently the retail space is unoccupied. 4. NYSERDA records credited the building with an annual gas savings of **11,263MMBtu**, but the gas consumption for the entire year of 2008 is only **4,162MMBtu**. 5. Nexant reccomends that there are no natural gas savings for this project. The heat content of the water in the insulated piping is provided by ground source water.

ERS Review Notes	1. Limited data was provided to evaluate electric impacts for this project. Electric impacts have been estimated as: Program gas impacts divided by 0.003414 (to convert to kWh) and divided by an assumed GSHP COP of 4.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF20

March 9, 2010

SUMMARY INFORMATION

Project ID	EF20
Program Being Evaluated	Existing Facilities
Customer Name	
Site Name If different	
Site Address	
Building or Site Type	Commercial

Principal Site Contact	
Title	
Phone	
Email	

IOU Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	
Phone	
Email	

Lead Evaluation Engineer	Shamus Cunningham
Report Author	Shamus Cunningham

1. PROJECT SUMMARY

The facility is a commercial laundry service that provides clean linen and valet washing for thirty-five to forty hotels in the NYC area. The facility operates washers 12-14 hours per day and ironing and finishing services 18-20 hours per day.

The measures involved replacing four existing conventional washers with a continuous batch washer, a grey water heat recovery system, a new air compressor with variable frequency drive-based part-load control and heat recovery, and a boiler stack economizer system.

1.1. Savings

Measure ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Continuous batch washer	Reported	0	0	7,901	$63,214
		Evaluated	257,100	55.9	8,823	
		Realization Rate	-	-	113%	
2	Air compressor heat recovery	Reported	0	0	548	$4,997
		Evaluated	87,300	10.0	246	
		Realization Rate	-	-	45%	
3	Boiler stack economizer	Reported	0	0	21,069	$19,194
		Evaluated	n/a	n/a	0	
		Realization Rate	n/a	n/a	0%	
4	Grey water heat exchanger	Reported	0	0	2,896	$23,171
		Evaluated	-20,600	-2.3	8,290	
		Realization Rate	-	-	286%	
Total		**Reported**	**0**	**0**	**13,453**	**$100,000** (capped)
		Evaluated	**323,800**	**63.6**	**17,360**	
		Realization Rate	**-**	**-**	**129%**	

1.2. Measure Sampling

Since the project involved four measures at a single site, sampling was not necessary.

1.3. Budget

Task	Hours	Cost w/ Expenses	
M&V plan	20	$2,600	
On-site M&V	32	$4,160	
Analysis	36	$1,680	**Site Evaluation**
Report	34	$3,910	**Cost / Incentive**
Total	**122**	**$15,350**	7.2%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The new Lavatec tunnel washer replaced conventional front loading washers. The washers operated 60 hours per week 50 weeks per year (approximately 3,000 hours a year). The washer specifications from the application are listed in Table 1 below:

Table 1:Application Baseline Performance Characteristics

Unit Water Use	2.5 gal/lb of laundry
Unit Steam Use	1.5 lb steam/lb of laundry
Unit Electricity Use	0.120 kWh /lb of laundry
Unit Gas Use	2,400 Btu/lb of water evaporated

The project documentation did not list the model number or quantity of conventional washers that were replaced. The site contact was not aware of the specifics of the types of washers that were replaced during this project as the retrofit took place before he began work at the site. The analysis worksheet contained in the application assumed that four machines with a total capacity of 2,200 lb/hr were replaced by the new Lavatec system.

2.1.2. Evaluation Description of Baseline

Baseline technology. Prior to 2006 the facility had only batch washers and primarily served the heavily soiled (e.g., food service) laundry market. Facility staff installed a tunnel washer in 2006 to wash lightly soiled laundry (e.g., hotel towels and bed linens) and grow business in this market. Operators continued to use batch washers for more heavily soiled laundry and valet cleaning.

Facilities staff reports that the new tunnel washer installed for this project represents an expansion of the site's lightly soiled washing capacity. Heavily soiled laundry continues to be handled by batch washers on-site. Bill data affirms the expansion. Therefore evaluators consider this project to be industrial process expansion.

Interviews with laundry industry design consultants, equipment manufacturers, and other similar laundry facilities has affirmed that open pocket laundry machines represent the least efficient option that a facility could reasonably install in a new process construction project of this scale. The baseline technology is the same open pocket washer as described in the program documentation.

Open pocket washer systems are similar in style to domestic washing machines in that they are batch washers (one load at a time) and use multiple hot wash and rinse fills to perform the cleaning action. This water is expelled to the drain without any reuse in the washing process. The lack of any water reuse leads to increased hot water consumption and steam use per pound of clean linen processed. Analysis of the washing recipes as well as interviews with laundry system design consultants has led us to decrease the estimated steam usage per pound of linen processed.

Baseline technology efficiency. For industrial measures, savings is calculated as the difference between the installed and baseline production efficiency (energy/unit production) at post-retrofit production rates.

Analysis of the washing recipes as well as interviews with laundry system design consultants has led us to use a lower baseline steam usage per pound of linen processed than the project application. Interviews with laundry design consultants, washer manufacturer representatives, and site staff and historical bill data all pointed to the fact that the baseline steam usage used in the application analysis was too high. Using the recipe and temperature setpoints provided by the site contact for their remaining front loading washer (see Table 2), the total baseline steam usage was calculated and converted to lbs steam/lbs dry laundry. The calculated figure of 0.8 lbs steam/lbs dry laundry was supported by bill data and confirmed by laundry design consultants and washer manufacturer representatives as being reasonable and that the application's 1.2 lb steam/lb dry laundry was well outside a reasonable expected range[1][2][3].

[1] Bob Beddingfield, Laundry Consulting – Personal Interview, 2 Feb. 2010.

[2] Steve Wilbur, Braun Washer Technical Representative – Personal Interview, 3 Feb. 2010.

[3] Western State Design, - Personal Interview, 10 Feb. 2010.

Table 2: Baseline Steam Usage Calculations

Washer Properties	
Dry Weight Laundry Capacity (lbs)	135
Water in each cycle (Gallons)	81
Inlet Water Temp (F)	105

Water Properties	
Specific Heat (Btu/lbs*F)	1
Density (lbs/gallon)	8.3
BTU/lbs steam	1000

Laundry Properties	
Specific Heat (Btu/lbs*F)	0.31

Recipe Setpoints (light soiled)			Energy Input to Water (BTUs)	Energy Input to Laundry (BTUs)
Fill 1 (F)	160		36,977	1,256
Fill 2 (F)	160		36,977	
Fill 3 (F)	140		23,531	
Fill 4 (F)	120		10,085	
Fill 5 (F)	105		-	
		Sum	**107,568**	**1,256**

Energy Summary	
Total lbs-steam	108.8235
lbs-steam/lbs laundry	0.8061

Interviews with laundry design consultants, washer manufacturer representatives, and site staff all pointed to the fact that the baseline steam usage used in the application analysis was too high. Using the recipe and temperature setpoints provided by the site contact for their remaining front loading washer (see Table 2), the total steam usage was calculated and converted to lbs steam/lbs dry laundry. The calculated figure of .8 lbs steam/lbs dry laundry was confirmed by laundry design consultants and washer manufacturer representatives (see Table 3).

Table 3: Evaluation Baseline Performance Characteristics

Unit Water Use	2.5 gal/lb of laundry
Unit Steam Use	0.8 lb steam/lb of laundry
Unit Electricity Use	0.120 kWh /lb of laundry
Unit Gas Use	2,400 Btu/lb of water evaporated

Baseline and post-retrofit production rate. Trended data from the Lavatec tunnel washer has documented the total number of loads of laundry, load weights, and time of completion for each load since the washer was installed. This internal database was used to help calculate savings on a per pound of dry linen basis.

2.1.3. Seasonal Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has shown consistent production growth between 2006 and 2010 with minimal seasonal variation.

2.1.4. Application Description of As-Built Equipment and Operation

According to the application documentation, a single Lavatec LT60-14BT tunnel washer replaced four conventional open-pocket washers. The tunnel washer (also known as continuous batch washer) has fourteen sections and each section can be configured to have different water temperatures and varying water levels. The laundry moves through each section of the machine where a different washing process occurs. Water is recycled in this machine with the cleanest water being used for the final rinse and the dirtiest water being used for the presoak stage. This counter-flow water reuse design accounts for the majority of the hot water savings. The tunnel uses direct steam injection in order to achieve the necessary water temperature setpoints in each of the fourteen sections. These setpoints are specified by the site's chemical provider. In order for the chemical reactions, which provide the cleaning power, to occur at a satisfactory rate, the cleaning process must achieve 160°F for a sustained period.

According to the project documentation, interviews with the site contact, and analysis of the Lavatec database, tunnel washer is used for towels approximately 60% of the time and for bed linen the rest of the time.

The front-loading open-pocket washers, which were reported to be replaced by the new tunnel washer, no longer reside in the building. Other similar conventional washers, which were part of a 2008/2009 tunnel washer installation, are still on-site and are occasionally used for high-bleach loads.

The installed tunnel washer performance characteristics as provided in the project documentation are listed in Table 4 below.

Table 4: Application Tunnel Washer Performance Characteristics

Unit Water Use	1.0 gal/lb of laundry
Unit Steam Use	0.7 lb steam/lb of laundry
Unit Electricity Use	0.068 kWh /lb of laundry
Unit Dryer Gas Use	1,755 Btu/lb of water evaporated

As can be seen from comparisons between Tables 3 and 4, the measure installation should also have resulted in electric savings. These savings are addressed in section 2.1.11

Four Fulton boilers (M#VMP 49.5) generate steam for use in the process and have a nameplate efficiency of 82%. This nameplate efficiency was used in all of the application's savings calculations for all four measures.

The equipment operation was confirmed during the site visit.

2.1.5. Measure Life

Specific measure life details are not available for the washers.

2.1.6. Applicant Energy Savings Algorithms

The energy savings reported in the original project documentation were calculated as follows:

The rate at which the laundry was processed in the front-loading open-pocket washers (baseline case) was first obtained.

- A process rate of 2,200 lbs/hr was derived after determining the total capacity and loading rate of the old system.
- The analysis assumed that the four baseline washers averaged 321 lbs/load at 21 loads/day.
- The 26,964 lbs/day was assumed to operate for 250 days per year for an annual total of 6,603,429 lbs/year.

The conventional (baseline) and continuous (as-built) washer performance data was used to calculate the water and steam used for the different systems.

The measure's steam savings were calculated by multiplying the annual lbs of laundry processed by the difference in steam usage (lb steam/lb laundry), as described in section 2.1.2 and 2.1.4. The applicant's savings algorithm assumed that the baseline washers consumed 1.5 lb steam/lb laundry and the new washers consume 0.7 lb steam/lb laundry. The source of the improvement in efficiency was not explained nor substantiated with manufacturer specs within the program documentation. This steam savings was converted to natural gas savings using a conversion factor of 1,000 Btu/lb steam and a boiler efficiency of 82%.

Dryer savings were also claimed for this project, which are derived from an improvement in efficiency of the new dryers as measured in Btu/lbs water evaporated. The applicant's savings algorithm assumed that the baseline dryers consume 2,400 Btu/lb whereas the new dryers are stated to consume 1,755 Btu/lb. The source of the improvement in efficiency was not explained nor substantiated with manufacturer specs within the program documentation.

The applicant's savings algorithm (see Table 5) assumed that 0.55 lbs of water was contained in every lb of linen when it left the washer and was loaded into the dryer. This value remained constant for both the baseline and tunnel washer systems. In addition, the analysis assumes that all laundry coming out of the washers goes through a full dry cycle in the dryers.

In order to be conservative, the total savings of the new system was discounted by 10% in the application analysis spreadsheet.

Table 5: Application Savings Algorithm

Application Savings Algorithm		
Baseline		
Machine capacity	321	lb
Number of shifts	2	shifts/day
Work hours per shift	6	hrs/shift
Total work hours	12	hrs/day
Number of days operating per year	250	
Annual operating hours	3,000	
Number of loads per day	21	loads
Number of machines	4	machines
Total pounds of laundry processed per day	26,398	lbs/day
Total pounds of laundry processed per hour	2,200	lbs/hr
Total pounds of laundry processed per year	6,599,535	lbs/yr
Baseline Energy Use		
Unit water use	2.5	gal/lb of laundry
Total water use	5,500	gal/hr
Unit steam use	1.5	lb steam/lb of laudry
Total steam use	3,300	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	40.2	therms/hr
Unit water evaporated	0.55	lb of water/lb of laundry
Total water evaporated	1,210	lb of water/hr
Unit gas use	2,400	Btu/lb of water evaporated
Total gas energy for evaporation	29.0	therms/hr
Total baseline gas usage	69.3	therms/hr
Annual baseline gas usage	207,837	therms/yr
Installed Energy Use		
Unit water use	1.0	gal/lb of laundry
Total water use	2,200	gal/hr
Unit steam use	0.7	lb steam/lb of laudry
Total steam use	1,540	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	18.8	therms/hr
Unit electricity use	120.8	kW
Unit water evaporated	0.55	lb of water/lb of laundry
Total water evaporated	1,210	lb of water/hr
Unit gas use	1,755	Btu/lb of water evaporated
Total gas energy for evaporation	21.2	therms/hr
Total installed system gas usage	40.0	therms/hr
Annual baseline gas usage	128,819	therms/yr
Savings		
Total gas savings	79,017.8	therms/yr

2.1.7. Evaluation Energy Savings Algorithms

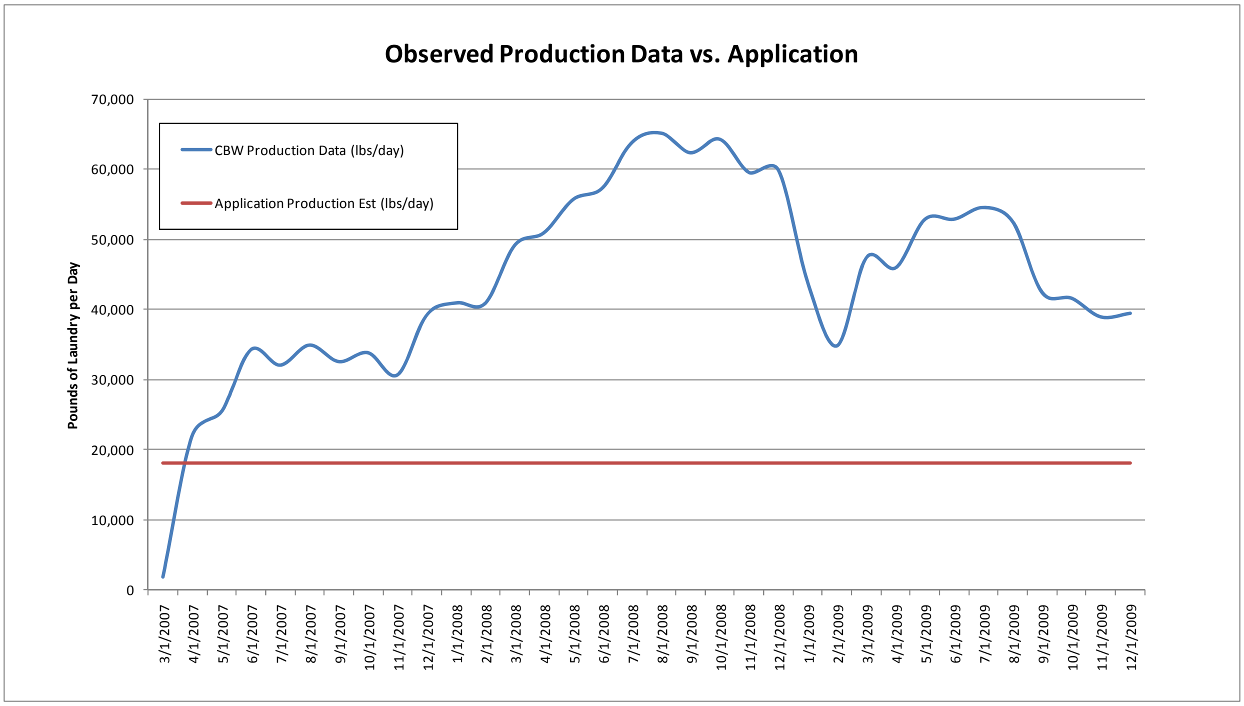
In general, the evaluators found the algorithms used in the application were appropriate in terms of methodology. However, we received little documentation or engineering data to support the numbers used in the calculations. The evaluators adjusted the algorithms to more appropriately account for the ways in which the laundry is processed through the drying process and to more accurately reflect the energy use of these machines. The following is a brief summary of the adjustments made, which are addressed in detail in this section:

- Boiler efficiency reduced to 78.2%
- Baseline washer steam usage reduced to 0.8 (lb steam/ lb laundry)
- Installed washer steam usage reduced to 0.5 (lb steam/ lb laundry)
- Water evaporated in drying process reduced to:
    - Conditioned laundry: 0.2 (lb water/ lb laundry)
    - Full dry laundry: 0.51 (lb water/ lb laundry)
- Installed dryer gas use increased to 2,000 (Btu/lb water evaporated)
- Logged production rates were used as the basis for annual process load

Laundry Production Data

The energy use and corresponding potential savings for all of the equipment in this project are directly proportional to the amount of laundry processed. Using the production data saved within the Lavatec tunnel washer control system, the total gas savings were calculated on a per–pound-of-dry-laundry-processed basis (therms/lb). The total amount of laundry processed in the Lavatec washer was significantly more than what was estimated in the application. The total system capacity of the new washer was much higher than the front-loading washers that were included in the original application. Because of the large increase in production, savings were calculated as if this were a facility expansion, and they were based off of the installed system’s monthly production and the increase in efficiency, on a per lbs of laundry processed level.

Figure 1: Tunnel Washer Production (as reported in Lavatec database)



Laundry Processing Split

Of the lightly soiled linen that the facility processes, there are two distinct drying patterns. Towels and linens that do not require ironing before they are returned to customers undergo a full drying cycle that removes all the water. This full-dry process lasts 20-30 minutes. Most of the linens (bed sheets and pillow cases) are ironed in the finishing process, which removes a significant amount of moisture from the linen, and are only "conditioned" in the Lavatec dryers for 2 to 5 minutes; just enough to break up the cake formed by the hydraulic press and remove some excess water.

Onsite interviews and an analysis of the Lavatec database determined that the mix between these two processes was approximately 60% full-dry linen and 40% conditioned linen by weight. In addition, laundry was sampled and weighted at the three points in the drying process to determine the amount of water removed in each of the process steps.

These two processes needed to be analyzed separately so that the gas usage associated with drying the linen could be accurately characterized. Because no changes were made to the ironing process and the time to iron the same items from either the site's batch or tunnel washers is reported to be the same, it was important not to assign any additional dryer savings to water which was removed in the finishing process.

Table 6: Full Dry/Conditioned Linen System Characteristics

Laundry Split	Wet	Conditioned	Full Dry
Production %	0%	40%	60%
Towel Weight	1.94	1.69	1.28
lbs water/# dry laundry	0.51	0.32	-

Installed Tunnel Washer System

The water consumption performance specs contained within the program documentation for the CBW tunnel washers were confirmed to be accurate in interviews with laundry design consultants and washer manufacturer representatives. However, the thermal energy specs for washer's steam usage as well as the dryer energy usage were determined to be inaccurate and as such the performance characteristics were adjusted. No manufacturer specifications could be found to verify the claimed 1,755 Btu/lb water evaporated in the program data, nor was it confirmed through discussions with manufacturers. Dryer logged data was unable to determine the total gas usage of the system because there was no observed difference in the combustion blower between high fire and low fire during the logging period. Market research and interviews with industry experts indicate that new highly efficient commercial tunnel washer systems average 2,000 Btu/lb water evaporated and so the analysis was changed to reflect this. The unit steam usage was adjusted down to 0.5 lb steam/lb laundry due to market research, interviews with industry experts, and logged data of the sites boilers. The table below presents the resource consumption values used in the evaluation calculations[4][5][6].

Table 7: Application CBW Performance Characteristics

Unit Water Use	1.0 gal/lb of laundry
Unit Steam Use	0.5 lb steam/lb of laundry
Unit Electricity Use	0.068 kWh/lb of laundry
Unit Dryer Gas Use	2,000 Btu/lb of water evaporated

Savings Algorithm

A calculation method similar to the applicant's algorithm was used with the modified energy usage constants and a means to separate full-dry and conditioned linen (see Table 8). Natural gas savings was calculated for 1 pound of dry linen. Steam savings were calculated by multiplying the new steam usage constant by the total monthly pounds of laundry processed. Dryer savings were calculated using the measured moisture content levels and the observed laundry percentage that underwent full-dry and conditioning process.

[4] Bob Beddingfield, Laundry Consulting – Personal Interview, 2 Feb. 2010.

[5] Steve Wilbur, Braun Washer Technical Representative – Personal Interview, 3 Feb. 2010.

[6] Western State Design, - Personal Interview, 10 Feb. 2010.

The normalized savings (therms/lb) were multiplied by the monthly production from the Lavatec database and summed to determine the annual savings.

Table 8: Evaluation Savings Algorithm

Modified per Pound Dry Linen Analysis					
Baseline					
Machine capacity		1			lb
Number of loads			0.4	0.6	loads
Pounds of laundry processed			0.40	0.60	lbs
Boiler efficiency		78.2%			
Cross Check					
Number of machines		1			machines
Total pounds of laundry processed per hour			0.40	0.60	lbs
Baseline Energy Use					
Unit water use		2.5			gal/# laundry
Total water use			1.00	1.50	gal/# laundry
Unit steam use		0.8			lbs steam/# laundry
Total steam use			0.32	0.48	lbs steam/# laundry
Energy per pound of steam		1,000			Btu/lb
Energy use for steam			0.00409	0.00614	therms/# laundry
Unit water evaporated			0.20	0.51	lb of water/# laundry
Total water evaporated			0.0780	0.3073	lb of water/# laundry
Unit gas use		2,400			Btu/lb of water evaporated
Total gas energy for evaporation			0.0019	0.0074	therms/# laundry
Total baseline gas usage			0.0060	0.0135	therms/# laundry
	sum	**0.0195**			therms/# laundry
Installed Energy Use					
Unit water use		1.0			gal/# laundry
Total water use			0.40	0.60	gal/# laundry
Unit steam use		0.5			lb steam/# laundry
Total steam use			0.20	0.30	lb steam/# laundry
Energy per pound of steam		1,000			Btu/lb
Energy use for steam			0.00256	0.00384	therms/# laundry
Unit water evaporated			0.2	0.5	lb of water/# laundry
Total water evaporated			0.08	0.31	lb of water/# laundry
Unit gas use		2,000			Btu/lb of water evaporated
Total gas energy for evaporation			0.00156	0.00615	therms/# laundry
Total installed system gas usage			0.00412	0.00999	therms/# laundry
	sum	**0.0141**			therms/# laundry
Total Savings		**0.0054**			therms/# laundry

Boiler Efficiency

Combustion tests were performed on the four 49.9-hp Cyclotherm boilers on-site to determine the relationship between process steam savings and gas savings. All four boilers were well maintained and in full operation while combustion tests were performed. Table 9 summarizes the testing results. The application used the nameplate boiler efficiency of 82%; this was changed to 78.2% in our analysis to reflect the combustion tests results.

Table 9: Boiler Combustion Test Summary

	Efficiency (%)	Ex Air (%)	O2 (%)	CO2 (%)	CO ppm
Boiler 1	78.5%	41.0%	6.1%	8.4%	1
Boiler 2	78.7%	78.7%	4.9%	9.1%	0
Boiler 3	77.8%	52.0%	7.2%	7.7%	0
Boiler 4	77.6%	41.0%	6.1%	8.4%	2
Average	78.2%	53.2%	6.1%	8.4%	75.0%

Evaluated Savings

Even through the efficiency of the tunnel washing system per pound of laundry was 60% less than the application's calculations, the underestimation of the total system production led to a total energy savings realization rate of 113% in 2009. The realization rate in 2009 dropped as total production through this tunnel washer decreased because of the addition of a second tunnel washer in January of 2009. The addition of a second washer removed a significant load from this machine and reduced the annual savings for this particular measure in 2009 relative to the prior year.

Figure 2: Normalized Monthly Evaluated Savings

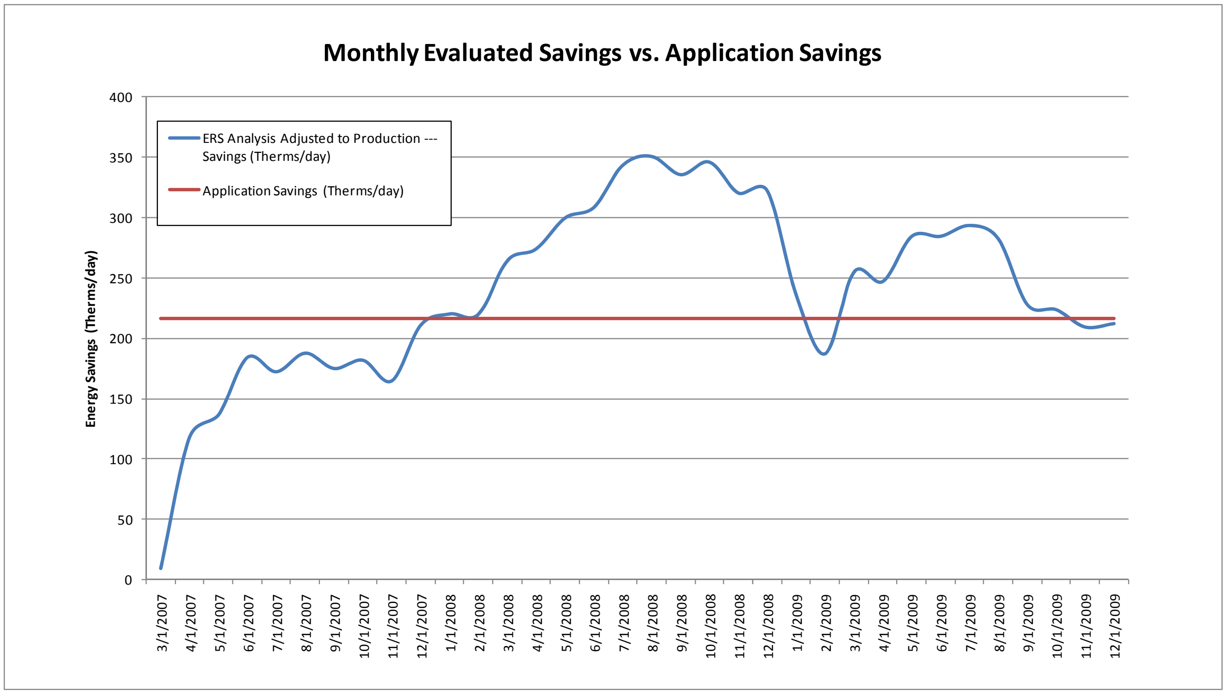


Table 10: Annual Realization Rates (2007-2009)

Year	Energy Savings Realization Rate	Production Realization Rate
2007	71%	158%
2008	139%	309%
2009	113%	252%

2.1.8. Data Measurement Method

Equipment monitored	Boilers	Washers
Parameter measured	Combustion efficiency	Performance data, operating hours, historical production
Measurement equipment	Combustion analyzer	Interview with the site staff & manufacturer, on-site observations, trended production data
Observation frequency	Spot measurement	N/A
Metering duration	N/A	N/A
Accuracy	± 1 % reading	N/A

2.1.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation and laundry system trend files, the analysis was conducted on an hourly basis. The hourly numbers were used to calculate the average monthly and annual values.

There is uncertainty regarding the unit energy use estimates. Both the baseline and installed energy use per unit production estimates rely in part on a combination of non-project specific data and expert interviews. While interviewers were confident in their performance estimates and had narrow estimates of the ranges for the values (nominally 5% to 10%), this introduces uncertainty. The experts did particularly assert that the application's baseline steam use per pound of laundry was well outside the plausible range.

Overall expected engineering accuracy including metering accuracy and uncertainties: 15%

2.1.11. Non-Energy Impacts

Tunnel washer systems have significant non-energy benefits beyond natural gas savings when compared to traditional open pocket systems. The four main sources of savings include electrical savings, reduced water consumption due to the technology's counter-flow design, reduced labor costs due to the automated transfer from washer to dryer, and reduced footprint in the industrial space.

Electrical Savings

Because the baseline efficiency system was no longer on-site it was not available for electrical metering. Due to the lack of baseline electrical use data the evaluators choose to rely on an industry study, which was able to perform full metering. ITRON completed a full electrical evaluation of a similar 3000lbs/hr tunnel washer system for the California Public Utilities Commission in 2008. It concluded that when compared to a new convention system the tunnel washer saved 55.9kW. The application which was reviewed in this CPUC evaluation also originally claimed an 80-90kw savings.

Year	kW Savings	Annual Washer Hrs	Average Electrical Rate ($/kwh)	Annual Savings (kWh)	Annual Savings ($)
2009	55.9	4600	$ 0.06	257,100	$ 14,700

Water Savings

Using the same per pound of linen processed method of calculating savings used described in Table 8 the water savings for this measure were calculated. The water usage specs for the baseline and installed technology were confirmed with industry experts and described in Tables 4 and 7.

Year	Water Savings (Gal)	Annual Savings @ $.008/gallon
2007	13,760,723	$ 110,100
2008	30,131,510	$ 241,100
2009	24,600,066	$ 196,800

Labor Savings

Because the tunnel washer automatically transfers linen from the washer to the extractor and finally to the dryer, the technology reduces the labor costs for the site. The machine is able to be operated by two workers, one to weigh and load the linen and another to unload the linen after it has finished the drying cycle. In conversations with the site contact and industry experts it was determined that a similar baseline technology system would require 1.5 additional Full Time Equivalents for a system of similar capacity.

Year	FTE Savings	Average Labor Cost per Hour	Annual Washer Hrs	Annual Savings
2009	1.5	18	4600	$ 124,200

Footprint Savings

The final non-energy benefit is the reduced footprint of the system when compared to similar conventional front loading systems. In addition to the smaller footprint of the machine, the automatic loading from the washer to the dryer eliminates the need for an overhead track system or paths for carts to move and manually transport linen from the washer to dryer. Average footprints for new open pocket and tunnel washing systems were determined and normalized to the capacity of the system installed at the evaluated site. Annual rent cost estimations were found through a survey of similar spaces in the Bronx.

Year	Footprint Savings (square ft)	Average Industrial Rent in Bronx ($/sq ft/yr)	Annual Savings
2009	800	16	$ 12,800

2.2. Measure ID#: 2

2.2.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

A new VFD water-cooled air compressor with heat recovery was installed at the site to replace an existing non-VFD air-cooled unit that did not recover heat.

The project documentation did not list the model number of air-cooled air compressor that was replaced by the new water-cooled VFD unit. The site contact was not aware of the specific performance characteristics of the prior air compressor that was taken out of service when the new unit was installed. The retrofit took place before he began work at the site.

Project documentation states that the air compressor heat exchanger displaces boiler capacity, which is assumed to operate at 82% efficiency.

The recovered hot water is fed into a tempered water tank that was previously heated using a gas water heater. According to discussions with the site contact a LUDEL direct-contact single-stage water heater is no longer in use because the recovered heat provided by the air compressor, grey water heat exchanger and vent condensers enough to maintain the required temperatures in both the hot and tempered water tanks.

2.2.2. Evaluation Description of Baseline

The baseline for this measure is considered to be the same as described in previous section. During the site visit the previous air compressor was observed, as it remains on-site as an emergency backup. The site visit verified that the old air compressor did not include any heat recovery hardware.

Nameplate data for the LUDEL direct-contact single-stage water heater was unavailable as it had been removed from the site when it was no longer needed. The hot and tempered water tanks are now heated with a steam coil if temperature drops below the setpoint. Steam is provided by four 49.9 hp Cyclotherm boilers, which operate as described in section 2.1.7

2.2.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has shown consistent production growth between 2006 and 2010 with minimal seasonal variation.

2.2.4. Application Description of As-Built Equipment and Operation

Installed equipment includes a 50-hp Ingersoll-Rand IRN50H-CC variable-speed rotary-screw air compressor and a waste heat recovery heat exchanger. The water-cooled air compressor recovers heat by using the incoming city water as a heat sink for both the compressor oil and the aftercooler.

The installed compressor performance characteristics as provided in the project documentation are listed below:

Table 11: Application Air Compressor Performance Characteristics

Cold temperature difference	75^{o}F
Hours of operation	3,000 hrs/year
Flow rate of cooling water	4.0 gpm
Boiler efficiency	82%

The measure installation also resulted in electric savings due to the upgrade to a VFD unit.

2.2.5. Measure Life

An evaluation of the measure life is not part of the scope of this project and will be assumed to be described in the project documentation.

2.2.6. Applicant Energy Savings Algorithms

The savings were calculated as follows:

The 4 gpm flow rate of the cooling water was converted to a mass flow rate (Mcw) using the density of water. This was then multiplied by the cold temperature difference (CTD) of 75^{o}F, as quoted from the manufacturer, and the specific heat of water (Cp) to determine the Btu/hr recovered.

- Heat transfer = Cp * CTD * Mcw

These calculations resulted in 149,940 Btu/hr recovered. This value was multiplied by the annual operating hours and then divided by the assumed boiler efficiency to determine annual gas savings of 5,485 therms. The hourly Btu heat recovery stood out because the electrical power supplied to the 50-hp air compressor is only 127,000 Btu/hr at full load

The operating hours were assumed to be 3,000 hours per year. A description of the methodology for how this number was obtained was not included in the project documentation.

Electric energy and demand savings were not calculated.

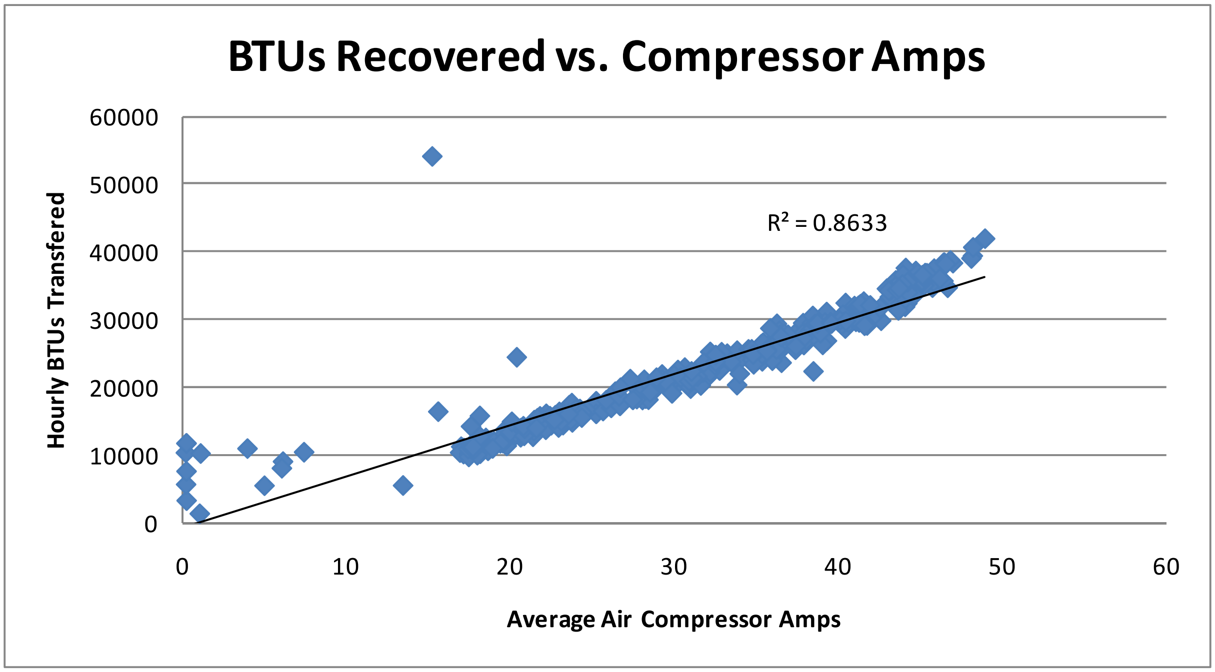
2.2.7. Evaluation Energy Savings Algorithms

The analysis approach is similar to that described in the previous section. The air compressor city water inlet temperature, heat exchanger exiting temperature, and total machine amps were logged at 1-minute intervals for 2 weeks. The system flow rate was confirmed on the manufacturer cut sheets to be 4 gpm and was assumed to be constant throughout the VFD range.

The flow rate of the cooling water was converted to a mass flow rate (Mcw) using the density of water. This was then multiplied by the measured cold temperature difference (CTD) and the specific heat of water (Cp) to determine the Btu/hr recovered.

Heat transfer = Cp * CTD * Mcw

Figure 3: Heat Recovery System Performance



Heat recovery was observed 24 hrs/day as the air compressor did not experience a significant down period in the 2 weeks in which data was logged. The system averaged 30,400 Btu/hr of heat recovery in the peak production hours between 7:00 AM and 2:00 PM and 17,750 Btu/hr in the off-peak production hours between 3:00 PM and 6:00 AM. The evaluators measured current to understand how heavily the air compressor was loaded during the measurement period so we could compare the measured heat transfer rate versus design at known load and calculate the electrical savings detailed in section 2.2.11. On average, the system recovered 34% of the electrical energy that was supplied to the air compressor.

The total annual energy savings was calculated by multiplying the 2-week average Btu/hr value of 22,009 by 8,760 hrs and dividing by the measured boiler efficiency of 78.2%. This resulted in an annual savings of 2,465 therms and a realization rate of 45%.

Table 12: Realization Rate

	Calcuated Savings	Projected Savings	
Average Energy Recovery Rate	22,009	149,940	btu/hr
Annual Opperating Hours	8760	3000	hrs/yr
Annual Savings	2,465	5,486	therms/yr
Realization Rate	**45%**		

Calculations

The maximum heat recovery of 149,940 Btu/hr, as projected in the original application, was never observed. The heat recovery rate for any one hour in the observed period was 54,000 Btu/hr. However, the runtime was much longer than the 3,000 annual hours that were anticipated in the application.

2.2.8. Data Measurement Method

Equipment monitored	**Boiler**	**Air Compressor**
Parameter measured	Combustion efficiency	Cold temperature difference, operating hours, cooling water flow rate
Measurement equipment	Combustion analyzer	Temperature loggers, amp loggers,
Observation frequency	Spot measurement	Temperature loggers – 2-week logging Amp logger – 2-week logging
Metering duration	N/A	2 Weeks
Accuracy	± 1 % reading	Temperature loggers ± 1 % reading Amp logger ± 1 % reading

2.2.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.2.10. Uncertainties

Based on information available in the project documentation, the analysis was conducted on a minute-by-minute basis. The hourly average numbers were used to calculate the average yearly values, which were assumed to be constant from month to month.

2.2.11. Non-Energy Impacts

The installation of a new VFD air compressor to serve the facility resulted in significant electrical savings. This measure was not incentivized by any other NYSERDA electrical programs. The Ingersoll Rand Nirvana 50-hp VFD air compressor was compared to a standard efficiency Ingersoll Rand Sierra 50-hp compressor.

The evaluators used 20 days of logged amp data and the compressor's performance curves (see Table 13) to determine the minute-by-minute compressor cfm production. This production was then used with the performance curve of the baseline efficiency unit to determine the electrical savings (see Table 14).

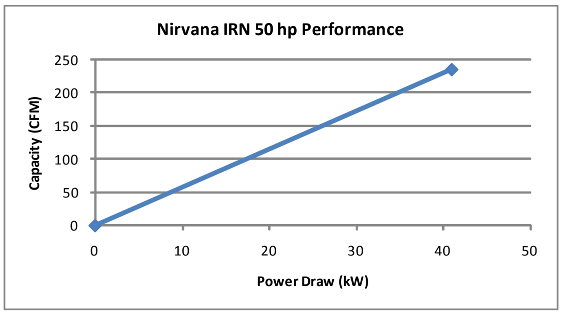
Table 13: Air Compressor Performance Characteristics

Installed System

Nirvana IRN 50 hp Performance Data 0.1898

Motor kW	Capacity (CFM)	Capacity (CFM) (Regressed)			y=mx+b
0	0	0	kW/CFM	Slope (m):	5.732
41	235	235	0.1745	b:	0.00

Data obtained from manufacturer



Baseline System

SSR-EP 50 hp Performance Data 0.1884

Motor kW	Capacity (CFM)	Power Draw (kW) (Regressed)			y=mx+b
20	0	20	kW/CFM	Slope (m):	0.093
40	214	40	0.1865	b:	20.00

Data obtained from manufacturer

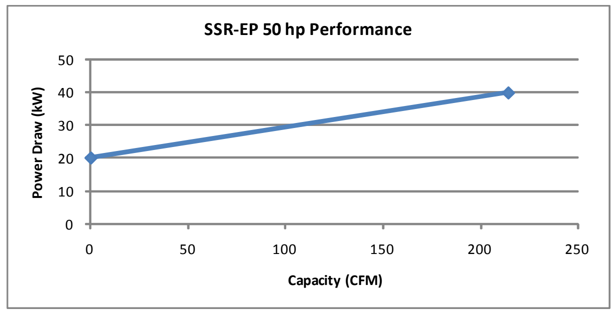


Table 14: Sample Minute-by-Minute Calculations

Date & Time	Installed System Nirvana IRN 50 hp		Baseline System Sierra 50 hp		Demand Savings (kW)
	kW	CFM	CFM	kW	
2/10/10 15:00	12.9	74	74	20.4	7.4
2/10/10 15:01	15.3	88	88	22.3	7.0
2/10/10 15:02	16.6	95	95	23.3	6.7
2/10/10 15:03	17.8	102	102	24.2	6.5

Year	kW Savings	Average Electrical Rate ($/kwh)	Annual Savings (kWh)	Annual Savings ($)
2009	9.97	$ 0.06	87,300	$ 5,000

2.3. Measure ID#: 3

2.3.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

A direct-contact Boiler Stack Economizer is used to preheat boiler make-up water by spraying it into the boiler exhaust. Project documentation states that the stack economizer displaces boiler capacity, which is assumed to operate at 82% efficiency. All four boiler exhausts are connected through a single header, which is connected to the economizer.

2.3.2. Evaluation Description of Baseline

Through discussions with the site contact it was determined that this system is no longer in use because of the incompatible nature of a direct contact heat exchanger and the way the system utilizes steam and hot water in the laundry process. Incomplete combustion carbon products were being collected by the feed water when it was passed through the heat exchanger resulting in carbon stains in the laundry process. Damages caused by this system forced the site to discontinue use of the economizer.

2.3.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has show consistent production growth between 2006 and 2010 with minimal seasonal variation.

2.3.4. Application Description of As-Built Equipment and Operation

The installed equipment includes the boiler stack economizer as well as the exhaust header.

The installed stack economizer performance characteristics as provided in the project documentation are listed in Table 15.

Table 15: Application Economizer Performance Characteristics

Heat exchanger effectiveness	90%
Hours of operation	3,000 hrs/year
Flow rate of water into heat exchanger	95 gpm
Boiler efficiency	82%
Boiler exhaust temperature	335°F
Average boiler load	85%

This measure did not result in additional electric usage due to additional fans and pumps because it is no longer in use.

2.3.5. Measure Life

An evaluation of the measure life is not part of the scope of this project and will be assumed to be the same as described in the project documentation. The persistence for this measure at this particular application was less than one year.

2.3.6. Applicant Energy Savings Algorithms

The savings were calculated as follows:

Given:

- Thfg = Temperature of flue gas leaving boiler – 335^{o}F
- Ehx = Effectiveness of heat exchanger – 90%
- Tcw = Temperature of city water – 55^{o}F
- Fcfg = Temperature of flue gas leaving economizer
    - Fcfg = Thfg – (Ehx(Thfg-Tcw)) = 83^{o}F
- Mhfg = Mass of flue gas – 3975.2 lbs/hr
- Hi = Enthalpy of flue gas @ 335^{o}F – 191.8 Btu/lb
- Ho = Enthalpy of flue gas @ 83^{o}F – 46.9 Btu/lb
    - Energy Transfer = Mhfg*(Hi-Ho) = 575,893.9 Btu/hr

This value was multiplied by the annual operating hours and then divided by the assumed boiler efficiency to determine annual gas savings of 21,069 therms.

Electric energy and demand savings were not calculated and are not considered in the scope of this study.

2.3.7. Evaluation Energy Savings Algorithms

This measure was verification only. The system is no longer in use and thus no savings are being seen from its installation.

2.3.8. Data Measurement Method

Verification only

2.3.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.3.10. Uncertainties

Overall expected engineering accuracy including metering accuracy and uncertainties: 5%

2.3.11. Non-Energy Impacts

No non energy impacts were seen at this site as a result of this measure.

2.4. Measure ID#: 4

2.4.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

A waste-water heat exchanger was installed to recover heat from the grey water storage tank before water is rejected to the sewer. The recovered heat replaced thermal input from a Ludel DC-4500 direct contact heat exchanger. The project documentation did not list the specs of the water heater that was replaced by the grey water heat exchanger.

Project documentation states that the heat exchanger displaces boiler capacity, which is assumed to operate at 82% efficiency.

The recovered hot water is fed into a tempered water tank that was previously heated using a gas water heater. According to discussions with the site contact the LUDEL direct contact single stage water heater is no longer in use because of the recovered heat provided by the air compressor, grey water heat exchanger and vent condenser. These sources are enough to maintain the required temperatures in both the hot- and tempered-water tanks.

2.4.2. Evaluation Description of Baseline

Nameplate data for the LUDEL direct contact single state water heater was unavailable as it had been removed from the site when it was no longer needed. The removal of the direct contact hot water heater was a planned event that the site contact told the evaluators was going to occur regardless of the implementation of gas efficiency measures. Because of the design of the direct contact water heater, incomplete combustion products were contaminating hot water that was used in the washing process. The hot- and tempered-water tanks are now heated with a steam coil if temperature drops below the setpoint. Steam is provided by four 49.9-hp Cyclotherm boilers.

The baseline as such will be assumed to be a steam coil heated by the four 49.9-hp Cyclotherm boilers described in section 2.1.7. The average efficiency of 78.8% will be used to calculate the gas savings.

2.4.3. Seasonal Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has shown consistent production growth between 2006 and 2010 with minimal seasonal variation.

2.4.4. Application Description of As-Built Equipment and Operation

Installed equipment for this measure is comprised of a Kemco 6,540-gph waste-water heat exchanger. The heat exchanger uses an 88-gpm pump on the waste-water side and city pressure on the incoming water side to force water through a shell and tube heat exchanger, which raises the temperature of the makeup water in the tempered water storage tank to 110°F.

The installed heat exchanger performance characteristics as provided in the project documentation are listed in Table 16.

Table 16: Application Grey Water HX Performance Characteristics

Heat exchanger effectiveness	75%
Hours of operation	1,200 hrs/year
Flow rate of waste water into heat exchanger	88 gpm
City water average input temperature	55°F
Temperature of cooled waste water	70°F
Temperature of waste water	115°F
Boiler efficiency	82%

The measure installation resulted in additional electrical usage due to the additional waste-water pump. However, these additional electrical loads are not part of the scope of this gas savings evaluation.

The equipment operation was confirmed during the site visit.

2.4.5. Measure Life

An evaluation of the measure life in not part of the scope of this project and will be assumed to be as described in the project documentation.

2.4.6. Applicant Energy Savings Algorithms

The savings were calculated as follows:

The flow rate of the waste water was converted to a mass flow rate (Mcw) using the density of water. This was then multiplied by the temperature drop across the heat exchanger on the waste-water side, as quoted from the manufacturer, and the specific heat of water (Cp) to determine the Btu/hr recovered.

- Heat transfer = Cp * (115°F - 70°F) * Mcw

These calculations resulted in a 1,979,200 Btu/hr heat recovery rate. This value was multiplied by the annual operating hour estimation and then divided by the assumed boiler efficiency to arrive at an annual gas savings of 28,964 therms.

The operating hours were assumed to be 1,200 hours per year - 24 hrs/week and 50 weeks/yr. A description of the methodology for how this number was obtained was not included in the project documentation.

Electric energy and demand increases were not calculated.

2.4.7. Evaluation Energy Savings Algorithms

The grey water heat exchanger system was logged using two thermocouples and a CT for a period of 2 weeks. Using a 1 minute sample time the thermocouples measured the temperature drop across the grey water side of the heat exchanger and the CT measured the amps of the grey water pump. An ultrasonic flow measurement was attempted on-site but was unsuccessful because of the amount of air and solids in the flow. As such, the flow on the grey water side was assumed to be the same as in the cut sheets contained in the program documentation: 88-gpm.

The total heat transfer rate of the system was calculated on a minute-by-minute basis. The flow rate of the waste water was converted to a mass flow rate (Mcw) using the density of water. This was then multiplied by the metered temperature drop across the heat exchanger on the waste-water side and the specific heat of water (Cp) to determine the heat recovery rate in Btu/min.

- Heat transfer (Btu/min) = Cp * (T_grey_in- T_grey_out) * Mcw

Table 17: Sample of Savings Calculation Spreadsheet

Timestamp	Pump CT (Amps)	T1 (F)	T2 (F)	Delta T (F)	Pump GPM	Heat Transfer Rate (Btu/min)
2/16/2010 10:14	10.876	78.471	126.03	47.559	88	34,863
2/16/2010 10:15	10.901	81.421	125.836	44.415	88	32,558
2/16/2010 10:16	10.608	75.985	125.643	49.658	88	36,401
2/16/2010 10:17	10.925	70.372	125.449	55.077	88	40,374
2/16/2010 10:18	10.828	66.344	125.578	59.234	88	43,421
2/16/2010 10:19	10.828	63.648	125.449	61.801	88	45,303
2/16/2010 10:20	10.095	61.59	124.808	63.218	88	46,341
2/16/2010 10:21	8.801	59.486	123.73	64.244	88	47,093
2/16/2010 10:22	0.012	57.117	122.79	65.673	0	-
2/16/2010 10:23	0.012	55.472	122.169	66.697	0	-
2/16/2010 10:24	0.012	54.516	121.674	67.158	0	-
2/16/2010 10:25	0.012	53.994	121.246	67.252	0	-
2/16/2010 10:26	0.012	53.776	120.817	67.041	0	-
2/16/2010 10:27	6.604	53.69	118.828	65.138	88	47,749
2/16/2010 10:28	6.726	53.298	117.939	64.641	88	47,384
2/16/2010 10:29	6.775	51.678	117.468	65.79	88	48,227
2/16/2010 10:30	6.995	49.604	117.117	67.513	88	49,490
2/16/2010 10:31	7.092	47.736	116.883	69.147	88	50,688

The total energy recovered was then summed by the hour and averaged across the 2-week period. The peak heat recovery of the system was observed to be 2,200,000 to 1,900,000 Btu/hr. This peak heat recovery rate was a very similar figure to the value in the original analysis. The total hours of operation are much longer than what was assumed in the analysis leading to the high realization rate.

Table 18: Measure Realization Rate Calculations

	Evaluated	Proposed	
Average energy recovery rate	740,096	1,979,208	Btu/hr
Annual operating hours	8760	1200	hrs/yr
Annual savings	82,906	28,964	Therms/yr
Realization Rate	**286%**		

2.4.8. Data Measurement Method

Equipment monitored	Boiler	Heat exchanger
Parameter measured	Combustion efficiency	Waste-water temperature difference, operating hours, waste-water flow rate
Measurement equipment	Combustion analyzer	Flow meter, temperature loggers, amp loggers
Observation frequency	Spot measurement	Flow meter – spot measurement Temperature loggers – 2-week logging Amp logger – 2-week logging
Metering duration	N/A	2 weeks
Accuracy	± 1 % reading	Flow meter ± 2-5 % reading Temperature loggers ± 1 % reading Amp logger ± 1 % reading

2.4.9. Site Sampling Strategy

Sampling strategy will not be necessary for this measure.

2.4.10. Uncertainties

Based on information available in the project documentation, the analysis will be conducted for annual compressor operation. The annual numbers will be used to calculate the average monthly values, which will be assumed to be constant from month to month.

Overall expected engineering accuracy including metering accuracy and uncertainties: 10%

2.4.11. Non-Energy Impacts

The additional grey water pump increased the sites electrical usage. The pump was logged with a CT for 20 days and the average amperage and spot measured voltage and power factor was used to calculate the electrical penalty for this measure.

Year	kW Savings	Average Electrical Rate ($/kwh)	Annual Savings (kWh)	Annual Savings ($)
2009	-2.335	$ 0.06	-20,500	$ (1,200)

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Measure 1: Tunnel Washer

The application savings calculations overestimated the savings on a per pound of laundry processed basis, meaning that the efficiency values (therms/lb and Btu/lb) were high for the baseline and low for the proposed, reducing the savings by 63%. However, the new system processed 250%-300% of the annual laundry estimates contained in the application increasing the savings correspondingly and more than offsetting the efficiency adjustment. The evaluation also found lower boiler efficiency, which increased the savings by about 5%, and found lower drying load, which decreased by about 25%. The measure resulted in a realization rate of 113%.

Measure 2: Air Compressor Heat Recovery

The application savings calculations overestimated the temperature difference across the heat exchanger. The manufacturer quoted a temperature difference of 75°F. The average observed temperature difference was only 11°F. However, the running hours were much longer than the 3,000 annual hours that were used in the calculations. The air compressor did not show a significant downtime during the 2-week logging period. As such, the hourly savings were only 15% of the application's value but the annual savings were 45% of the application's calculations.

Measure 3: Direct-Contact Boiler Economizer

During the site visit the economizer was observed to be installed. However, because the economizer was collecting incomplete combustion products in the boiler exhaust and depositing the carbon in the laundry, the system was permanently taken out of service.

Measure 4: Grey Water Heat Recovery

The calculated temperature difference across the heat exchanger was observed during the logging period to be very similar to the application savings calculations. However, the weekly operating hours were much longer than the 24 hrs/week estimate used in the application. Our logging of the system showed an average run time of 51.3 hrs/week. This longer run time was the source of the high realization rate.

3.2. Deviations from M&V Plan

The only major deviation from the original plan occurred when it was determined on-site that the Lavatec washers contained an internal database of every load of laundry that the machines had processed. This allowed the analysis for Measure 1 to be calculated on an hourly and monthly basis rather than the annual basis.

3.3. Recommendations for Program Designers & Implementers

The total savings of Measure 1 may be misleading as the production was significantly underestimated in the application savings algorithm. For all future projects the baseline energy usage of the open pocket (conventional) washers should be more closely scrutinized, as the figures used in this project as well as others we have evaluated have been significantly higher than our observed values.

3.4. Customer Alert

None. The site contact was extremely helpful and more than willing to discuss energy efficiency opportunities.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	
Building predominant year of construction	

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/25/2010
Site visit date(s)	1/14/2010, 2/10/2010, 3/2/2010
Draft site report completion date	3/9/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF21

April 14, 2010

SUMMARY INFORMATION

Project ID	EF21
Program Being Evaluated	Existing Facilities
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Manufacturing
Principal Site Contact	
Title	
Phone	
Email	
NYSERDA Representative	
Phone	
Email	
Third Party Contact	
Title	
Company	
Phone	
Email	
Lead Evaluation Engineer	Yogesh Patil
Plan/Report Author	Yogesh Patil

1. PROJECT SUMMARY

The facility manufactures fresh and frozen bagels. It occupies a total area of 60,000 square feet and currently operates two shifts a day, five days a week.

The project involved installation of the following equipment:

- Winkler sealed-unit bagel boiler (cooker)
- Winkler indirect-fired recirculation oven
- Loading conveyor, dryer, seeding conveyor, cooling conveyor, packaging machines, and walk-in coolers and freezers.

During the implementation of the project, the facility was planning on doubling the production capacity rate. Twenty different types of bagels are made at the facility.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Continuous batch washer	Reported	0	0	19,637	$284,865
		Evaluated	n/a	n/a	8,426	n/a
		Realization Rate	n/a	n/a	43%	n/a

It should be noted that a review of the savings calculations was conducted by an independent third-party engineering firm. The review indicated that gas savings are marginally higher (202,074 therms) than the tracking value.

1.2. Measure Sampling

Measure sampling was not necessary. All the installed gas saving equipment was evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	14	$1,792	
On site M&V	16	$1,978	
Analysis	32	$3,612	**Site Evaluation Cost / Incentive**
Report	24	$2,772	
Total	86	$10,158	3.6%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The bagel-making process involves two major gas intensive steps: boiling and baking. The bagel is boiled for a short time and then baked to set the crust. Prior to the installation of the new equipment, this was done using a Babbco cooker (bagel boiler) and Babbco oven.

The Babbco cooker is similar to an open kettle and was estimated to operate at high fire about 85% of the time.

The Babbco oven is a low-pressure-gas direct-fired oven and has 6 inches of fiberglass insulation. The unit has thirty burners (twenty-eight ribbon burners and two tube burners) with a total capacity of 5 MMBtu[1] per hour at high fire and 1.932 MMBtu per hour at low fire.

According to the project documentation, on average the baseline equipment produced approximately 12,000 dozen bagels per day and operated at 60% of its capacity.

2.1.2. Evaluation Description of Baseline

The baseline for this measure is considered to be the same as described in the previous section. The burner ratings were verified during the site visit, as the equipment remains on site.

The site contact reported that on average the baseline production was higher. The new boiler and oven are used to produce approximately 16,000 dozen bagels per day that otherwise would have been prepared with the baseline system. The equipment does not operate at full capacity.

According to the site contact, if operated at maximum capacity, the baseline equipment would have been able to operate at the post-retrofit production levels.

2.1.3. Seasonable Variability in Schedule and Production

Based on discussions with the site contact, the production varies from month to month. It is a function of market demand rather than season. The monthly production data was not available to determine the

[1] MMBtu = million Btu

variation pattern. Based on bill review the season does have a slight effect on gas use. To mitigate any influence the analysis used the same month-to-month period.

2.1.4. Application Description of As-Built Equipment and Operation

The project involved installation of the following equipment:

- Winkler sealed unit bagel boiler (cooker) – Since this unit is sealed, it loses less heat as compared to the older equipment. Thus, the unit fires natural gas at a lower input rate. The boiler consumes 0.75 MMBtu per hour at high fire and 0.25 MMBtu per hour at low fire.
- Winkler indirect-fired recirculation oven – The unit has 2 inches of fiberglass insulation, which reduces heat loss and operates at lower firing rate resulting in reduced gas consumption. The oven also recirculates the air within the oven. The oven has only one burner and consumes 2.5 MMBtu per hour at high fire and 0.5 MMBtu per hour at low fire.
- Loading conveyor, dryer, seeding conveyor, cooling conveyor, packaging machines, and walk-in coolers and freezers.

The company purchased the building next door and installed the above listed equipment to help increase the production capacity.

The baseline equipment is still in place and was intended to be used only when production exceeds the capacity of the new installed equipment. However, the old equipment is used one shift a day. The overall post-retrofit production is approximately 22,500 dozen bagels per day. The facility operates two shifts a day on weekdays.

Originally, the facility had two natural gas services – one for manufacturing and a second for all other uses. A new gas service was added to serve the new equipment.

2.1.5. Applicant Energy Savings Algorithms

The savings were calculated as follows:

The baseline gas usage for the Babbco cooker and oven was calculated by multiplying the burner rated high-fire and low-fire input values with corresponding operating hours at each setting.

Similarly, the post-implementation gas usage for the Winkler cooker and oven was calculated by multiplying the burner rated high-fire and low-fire input values with corresponding operating hours at each setting.

Based on the information in the project documentation, 70% of the time the ribbon burners operated on high-fire setting and 30% of the time on low-fire setting. Similarly, the tube burner operated on high-fire setting for 90% of the time and on low fire for the remaining 10% of the time.

Since the Winkler cooker and oven burners operate more hours at low-fire setting, the difference between the baseline and post-implementation gas usage was the savings.

2.1.6. Evaluation Energy Savings Algorithms

An analysis approach similar to that described in the previous section was adopted to determine the savings. However, two additional factors were considered:

1. The baseline conditions were normalized for production rates (therms/dozen bagels) and scaled up to match the higher post-retrofit production rates.
2. Both the baseline and post-retrofit results were reconciled with manufacturing area gas billing data. This included discussions with site staff and revising estimates of hours per year operation at high- and low-firing rates for both systems.

Since the analysis was performed using billing information, the burner high/low fire calibration was more for verification of discussion with the site staff.

2.1.7. Data Measurement Method

Equipment monitored	Cooker & oven
Parameter measured	Burner rated capacity, operating hours, % high-fire and % low-fire operating time breakdown
Measurement equipment	Actual metering was not conducted. The values were estimated based on discussion with the site staff and then calibrated using the actual billing data.
Observation frequency	N/A
Metering duration	N/A
Accuracy	N/A

2.1.8. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.9. Uncertainties

The gas usage is a function of production levels and the production level depends on the number of orders in hand (market demand). Excluding the long-term orders, it is difficult to predict the production levels that result in change of gas usage on a monthly basis.

Overall expected engineering accuracy including metering accuracy and uncertainties: 6%

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

There are three reasons for the discrepancy between reported and evaluated savings.

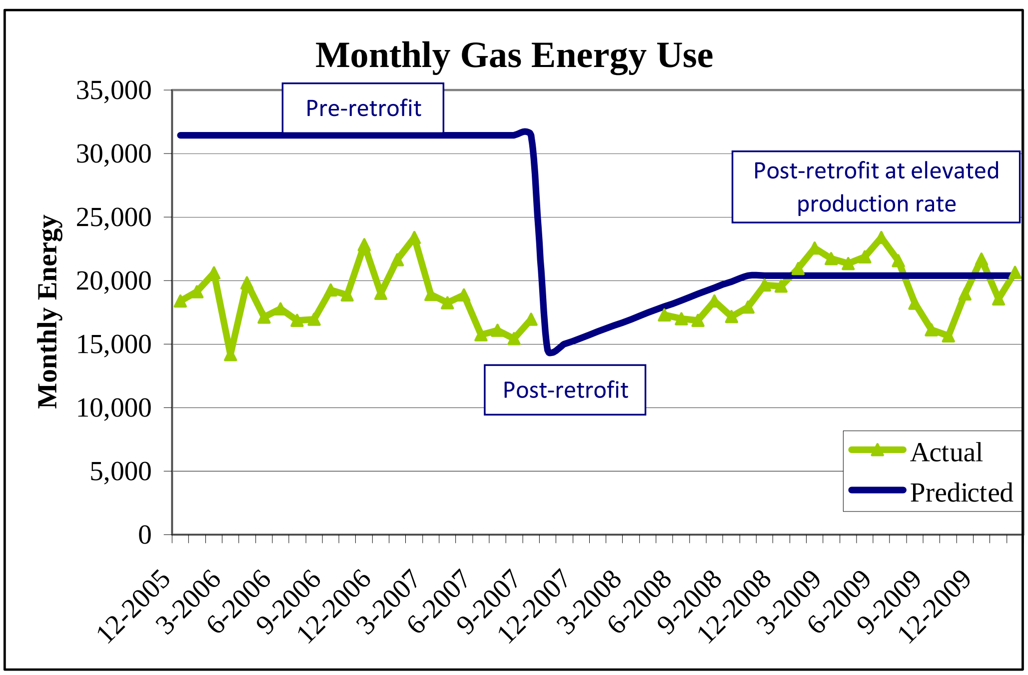
1. The tracking savings were based on assumed high-fire and low-fire operating time breakdown. According to the tracking savings analysis, the baseline annual gas use should be approximately 375,000 therms where as the actual billing data indicated that the annual gas usage was approximately 226,000 therms. The measure was expected to save about 50% of the boiler and oven gas use, but would have had to have saved 90% of total billed energy use to match predicted savings.

   Evaluators adjusted the high-fire and low-fire operating time in the evaluation savings analysis based on discussion with the site staff, and they calibrated using the actual billing data for both the pre- and post-retrofit case.

2. The original analysis assumed that the old system would be retired. Instead it continues to perform about 1/3 of the cooking, reducing savings correspondingly.

3. The post-retrofit production levels increased by 40%, which was not considered and could not have been predicted in the tracking savings analysis. This increases savings but does not offset decreases caused by the first two issues.

The graph below illustrates the comparison.



3.2. Deviations from Plan

In the original M&V plan we considered the billing analysis but did not consider including the production data. After discussion with the site staff and reviewing the gas bills, it was clear that production levels greatly influence the overall gas usage. Thus, the savings analysis was modified to include production data.

3.3. Recommendations for Program Designers & Implementers

There were no recommendations identified for program designers and implementers.

3.4. Customer Alert

The site staff was very friendly and promptly provided us with the required data. Based on our communication with the site staff, we do not foresee any issues with future contact for additional work.

3.5. Contextual Data

Electric/gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	33,000
Building predominant year of construction	1992

3.6. Evaluation Dates

Assignment date	12/8/2009
Plan approval date	1/11/2010
Site visit date(s)	2/9/2010
Draft site report completion date	4/12/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF22

June 18, 2010

SUMMARY INFORMATION

Project ID	EF22		
Program Being Evaluated	EF, Group A		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Manufacturing		
Customer Business/Product	Lighting fixtures		

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Dakers Gowans
Report Author	Dakers Gowans

1. PROJECT SUMMARY

The project consists of rebuilding and refurbishing the facility's powder-coat paint booth equipment. Steps included replacing burners with smaller capacity units, increased insulation levels in oven sections, incorporation of temperature zones in paint booth equipment, improved controls to lower oven temperature from approximately 400°F for the entire process to 300°F for the dry off phase and 340°F for the cure phase, new air curtains at oven entrance and exit points.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Replace/refurbish powder coat paint system	Reported	0	0	20,392	$40,784
		Evaluated			20,392	$40,784
		Realization Rate			1.0	
2		Reported			0	0
		Evaluated				
		Realization Rate				
3		Reported				
		Evaluated				
		Realization Rate				
4		Reported				
		Evaluated				
		Realization Rate				
Total		Reported				
		Evaluated				
		Realization Rate				

1.2. Measure Sampling

No sampling was performed on this site.

1.3. Budget

Task	**Hours**	**Cost Including Expenses**	
M&V plan	2	$300	
On site M&V	4	$600	
Analysis	3	$450	**Site Evaluation Cost / Incentive**
Report	2	$300	
Total	16	$1,650	4%%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	
Replacement of failed equipment	
Replacement of working equipment	X
Industrial process expansion	

The project involves replacement and refurbishment of a powder coat paint system including spray booth and cure oven. The application baseline was developed using nameplate data from gas burners, assumed hours of operation and assumed part load ratios. There was no correlation between production rates and gas use.

2.1.2. Evaluation Description of Baseline

The evaluation attempted to use Con Edison billing histories for the two gas accounts at the facility to establish the baseline gas consumption. Gas use is highly variable and no independent variable was identified to explain the variance. The obvious variable is production rates but these were not available from the facility.

2.1.3. Seasonable Variability in Schedule and Production

Based on interviews with facility managers, production rates and schedules are near constant.

2.1.4. Application Description of As-Built Equipment and Operation

The project involves replacement and refurbishment of a powder coat paint system including spray booth and cure oven.

2.1.5. Applicant Energy Savings Algorithms

Applicant used an engineering analysis approach to calculate ex ante estimates of baseline and post-retrofit performance. The savings was predicted to be 23% of the facility’s baseline gas use.

2.1.6. Evaluation Energy Savings Algorithms

The evaluator used natural gas billing records to measure baseline and post-retrofit whole-building fuel use.

2.1.7. Data Measurement Method

Equipment monitored	Billing records
Parameter measured	Billing records
Measurement equipment	Billing records
Observation frequency	Monthly
Metering duration	6 months baseline, 16 months post installation
Accuracy	100%
Uncertainty	Completeness of records

2.1.8. Site Sampling Strategy

No sampling was performed on this site.

2.1.9. Uncertainties

Fuel use is assumed to be a function of production rates measured in pounds of paint per day. The evaluation analysis assumed a constant production rate for the baseline and post-installation periods based on anecdotal accounts offered in interviews with plant personnel during the evaluator's site visit. Actual production records were not available to the evaluator so the steady state assumption could not be confirmed.

Overall expected engineering accuracy including metering accuracy and uncertainties: 100%

However, the results may not be reliable due to reliance on assumptions about production rates.

2.1.10. Non-Energy Impacts

Reduced labor requirements for changeover of oven system from one fixture type to another.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The evaluated results are the same as the reported results. A straight bill comparison, which would be valid under a constant-production, weather-independent scenario, shows an increase in monthly natural gas use during the post retrofit period of 10%. Because the production records could not be obtained, the billing records could not be normalized to the throughput of pounds of paint per day. Therefore the billing analysis results are unreliable and the evaluator accepts the calculated ex ante savings as the most accurate available estimates of true performance.

3.2. Deviations from Plan

The evaluator did not use the billing analysis results and the realization rate was left at 1.0.

3.3. Recommendations for Program Designers & Implementers

Require customer to supply the basic data needed to conduct M&V; in this case a full year of baseline oil deliveries and baseline and post-installation monthly paint use.

3.4. Customer Alert

There are no customer alerts.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	Unknown
Building predominant year of construction	Unknown

3.6. Evaluation Dates

Assignment date	January 2010
Plan approval date	NA
Site visit date(s)	March 10, 2010
Draft site report completion date	June 18, 2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms

☑ Sampling worksheets, if used

The following billing history data were analyzed for the evaluation review.

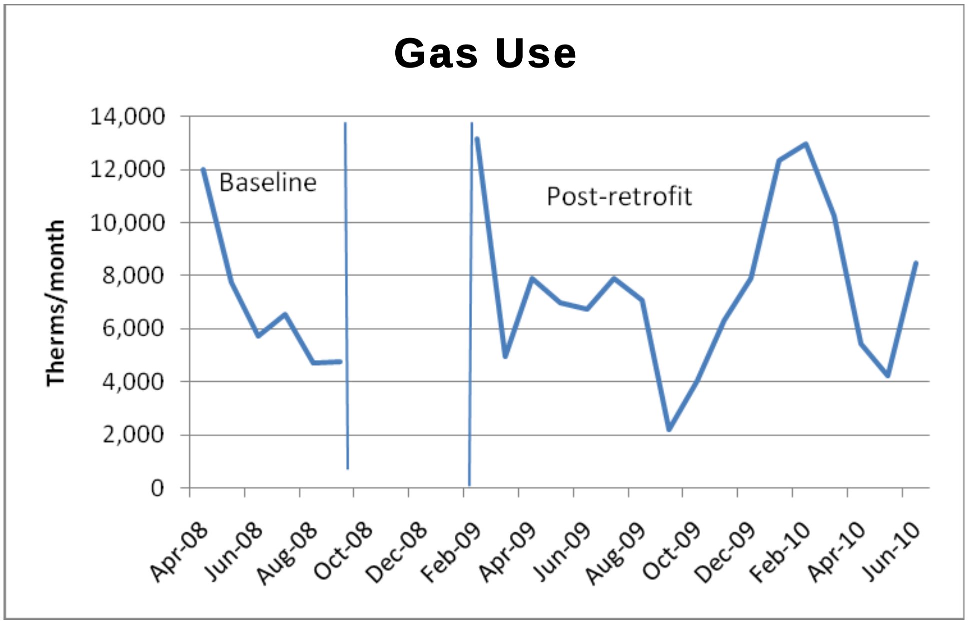
Table 1: Billing History Data

Period	From Date	To Date	Gas Use (therm)
Performance	5/6/2010	6/7/2010	8,500
	4/8/2010	5/6/2010	4,219
	3/10/2010	4/8/2010	5,451
	2/8/2010	3/10/2010	10,284
	1/7/2010	2/8/2010	12,977
	12/8/2009	1/7/2010	12,365
	11/4/2009	12/8/2009	7,879
	10/6/2009	11/4/2009	6,326
	9/4/2009	10/6/2009	4,020
	8/6/2009	9/4/2009	2,200
	7/8/2009	8/6/2009	7,055
	6/8/2009	7/8/2009	7,885
	5/7/2009	6/8/2009	6,753
	4/8/2009	5/7/2009	6,981
	3/10/2009	4/8/2009	7,877
	2/9/2009	3/10/2009	4,978
	1/7/2009	2/9/2009	13,144
Construction	12/5/2008	1/7/2009	
	11/3/2008	12/5/2008	
	10/3/2008	11/3/2008	
	9/4/2008	10/3/2008	
Baseline	8/5/2008	9/4/2008	4,771
	7/7/2008	8/5/2008	4,714
	6/5/2008	7/7/2008	6,531
	5/6/2008	6/5/2008	5,730
	4/7/2008	5/6/2008	7,764
	3/7/2008	4/7/2008	11,984

Table 2: Comparison of Baseline and Post-Retrofit Gas Use

Period	Therms/month
Baseline	6,916
Post-retrofit	7,582
% savings	-10%

Figure 1: Gas Use



The absolute difference between baseline fuel oil use and post-installation natural gas consumption is an increase of approximately 666 therms per month or an increase over baseline use of approximately 10%. The absolute difference does not account for changes in production, which will have a significant influence on gas use. Because no production data were available for the evaluation the absolute use could not be normalized for production and the savings calculated from a simple bill comparison (subtracting post-install from baseline use) are not reliable and were not used.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF23

March 15, 2009

SUMMARY INFORMATION

Project ID	EF23
Program Being Evaluated	Existing Facilities
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial

Principal Site Contact	
Title	
Phone	
Email	

IOU Representative	
Phone	
Email	

Third Party Contact	Eric Mueller
Title	
Company	Lavatec, Inc.
Phone	203-723-1122
Email	

Lead Evaluation Engineer	Shamus Cunningham
Report Author	Shamus Cunningham

1. PROJECT SUMMARY

The facility is a commercial laundry service that provides clean linen and valet washing for thirty-five to forty hotels in the NYC area. The facility operates washers 12-14 hours per day and ironing and finishing services 18-20 hours per day.

The measures involved replacing four existing conventional washers with a continuous batch washer.

1.1. Savings

Measure ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBTU/yr)	Incentive Value ($)
1	Continuous batch washer	Reported	0	0	29,669	$432,076.50
		Evaluated	257,100	55.9	4,542	
		Realization Rate			15%	

1.2. Measure Sampling

Since the project involved one measure at a single site, sampling was not necessary.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	20	$2,600	
On-site M&V	32	$4,160	
Analysis	36	$1,680	**Site Evaluation Cost / Incentive**
Report	34	$3,910	
Total	**122**	**$15,350**	3.5%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The new Milnor tunnel washer replaced five conventional front loading washers:

- Three Washex 700 lbs capacity washers
- One Braun 400 lbs capacity washer
- One Speed Queen 135 lbs capacity washer

The washers operated 18 hours per day 350 days per year (approximately 6,300 hours a year). The washer specifications from the application are listed below:

Table 1:Application Baseline Performance Characteristics

Unit Water Use	2.5	gal/lb of laundry
Unit Steam Use	1.5	lbs steam/lb of laundry
Unit Electricity Use	0.120	kWh / lb of laundry
Unit Gas Use	2400	Btu/ lb of water evaporated

The analysis worksheet assumed that five machines with an average capacity of 2,700 lbs/hr were replaced by the new Milnor system.

2.1.2. Evaluation Description of Baseline

Baseline technology. Prior to 2006 the facility had only batch washers and primarily served the heavily soiled (e.g., food service) laundry market. Facility staff installed a tunnel washer in 2006, not part of this project, to wash lightly soiled laundry (e.g., hotel towels and bed linens) and grow business in this market. Operators continued to use batch washers for more heavily soiled laundry and valet cleaning.

Facilities staff reports that the new tunnel washer installed for this project in 2008 represents an expansion of the site's lightly soiled washing capacity. Heavily soiled laundry continued to be handled by batch washers on-site. Bill data affirms the expansion. Therefore evaluators consider this project to be industrial process expansion.

Interviews with laundry industry design consultants, equipment manufactures and other similar laundry facilities has affirmed that open pocket laundry machines represent the least efficient option that a facility could reasonably install in a new process construction project of this scale. The baseline technology is the same open pocket washer as described in the program documentation.

Open pocket washer systems are similar in style to domestic washing machines in that they are batch washers (one load at a time) and use multiple hot wash and rinse fills to perform the cleaning action. This water is expelled to the drain without any reuse in the washing process. The lack of any water reuse leads to increased hot water consumption and steam use per pound of clean linen processed compared to tunnel washers, which reuse hot water.

Baseline technology efficiency: For industrial measures, savings is calculated as the difference between the installed and baseline production efficiency (energy/unit production) at post-retrofit production rates.

Analysis of the washing recipes as well as interviews with laundry system design consultants has led us to use a lower baseline steam usage per pound of linen processed than the project application. Interviews with laundry design consultants, washer manufacturer representatives, and site staff and historical bill data all pointed to the fact that the baseline steam usage used in the application analysis was too high. Using the recipe and temperature setpoints provided by the site contact for their remaining front loading washer (see Table 2), the total baseline steam usage was calculated and converted to lbs steam/lbs dry laundry. The calculated figure of 0.5 lbs steam/lbs dry laundry was supported by bill data and confirmed by laundry design consultants and washer manufacturer representatives as being reasonable and that the application's 1.2 lb steam/lb dry laundry was well outside a reasonable expected range[1][2][3].

[1] Bob Beddingfield, Laundry Consulting – Personal Interview, 2 Feb. 2010.

[2] Steve Wilbur, Braun Washer Technical Representative – Personal Interview, 3 Feb. 2010.

[3] Western State Design, - Personal Interview, 10 Feb. 2010.

Table 2: Baseline Steam Usage Calculations

Washer Properties	
Dry Weight Laundry Capacity (lbs)	135
Water in each cycle (Gallons)	81
Inlet Water Temp (F)	105

Water Properties	
Specific Heat (Btu/lbs*F)	1
Density (lbs/gallon)	8.3
BTU/lbs steam	1000

Laundry Properties	
Specific Heat (Btu/lbs*F)	0.31

Recipe Setpoints (light soiled)			Energy Input to Water (BTUs)	Energy Input to Laundry (BTUs)
Fill 1 (F)	160		36,977	1,256
Fill 2 (F)	160		36,977	
Fill 3 (F)	140		23,531	
Fill 4 (F)	120		10,085	
Fill 5 (F)	105		-	
		Sum	**107,568**	**1,256**

Energy Summary	
Total lbs-steam	108.8235
lbs-steam/lbs laundry	0.8061

Table 3: Evaluation Baseline Performance Characteristics

Unit Water Use	2.5 gal/lb of laundry
Unit Steam Use	0.8 Lbs steam/lb of laundry
Unit Electricity Use	0.120 kWh / lb of laundry
Unit Gas Use	2400 Btu/ lbs of water evaporated

Baseline and post-retrofit production rate. Trended data from the Lavatec tunnel washer has documented the total number of loads of laundry, load weights, and time of completion for each load since the washer was installed. This internal database was used to help calculate savings on a per pound of dry linen basis.

2.1.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has shown consistent production growth between 2006 and 2010 with minimal seasonal variation.

2.1.4. Application Description of As-Built Equipment and Operation

The application described the conventional washers as being replaced by a single Milnor 76039-08 tunnel washer. The tunnel washer (also known as continuous batch washer, CBW) has fourteen sections and each section can be configured to have different water temperatures and varying water levels. The laundry moves through each section of the machine where a different washing process occurs. Water is recycled in this machine with the cleanest water being used for the final rinse and the dirtiest water being used for the presoak stage. This counter-flow water reuse design accounts for the majority of the hot water savings. The tunnel uses direct steam injection in order to achieve the necessary water temperature setpoints in each of the fourteen sections. These setpoints are specified by the site's chemical provider. In order for the chemical reactions, which provide the cleaning power, to occur at a satisfactory rate, the cleaning process must achieve 160°F for a sustained period.

According to the project documentation, interviews with the site contact, and analysis of the washer database, the tunnel washer is used for towels approximately 60% of the time and for bed linen the rest of the time.

The installed tunnel washer performance characteristics as provided in the project documentation are listed in Table 4.

Table 4: Application CBW Performance Characteristics

Unit Water Use	0.9	gal/lb of laundry
Unit Steam Use	0.35	lbs steam/lb of laundry
Unit Electricity Use	0.068	kWh / lb of laundry
Unit Gas Use	1755	Btu/ lbs of water evaporated

As can be seen from comparisons between Tables 3 and 4, the measure installation also results in electric savings. These savings are addressed in section 2.1.11.

Four Fulton boilers (M#VMP 49.5) generate steam for use in the process and have a nameplate efficiency of 82%. This nameplate efficiency was used in all of the application's savings calculations for this measure.

During the site visit it was confirmed that the tunnel washer that was listed in the application was not of the make and model that was installed at the site. The model on-site was manufactured by Lavatec not Milnor as stated in the application.

2.1.5. Measure Life

Specific measure life details are not available for the washers.

2.1.6. Applicant Energy Savings Algorithms

The energy savings reported in the original project documentation were calculated as follows:

The rate at which the laundry would be processed through the installed equipment was first obtained.

- A process rate of 3,900 lbs/hr was derived after determining the total capacity and loading rate of the new system (85% of the maximum nameplate process rate).

- The 3,900 lbs/hr was assumed to operate for 5384 hours per year for an annual total of 21,000,000 lbs/year.
- After an interview with the site contact during the PIR the annual production estimate was lowered to 16,000,000 lbs/yr.

The conventional (baseline) and continuous (as-built) washer performance data was used to calculate the water and steam used for the different systems.

The measure's steam savings were calculated by multiplying the annual lbs of laundry processed by the difference in steam usage (lb steam/lb laundry), as described in section 2.1.2 and 2.1.4. The applicant's savings algorithm assumed that the baseline washers consumed 1.5 lb steam/lb laundry and the new washers consume 0.7 lb steam/lb laundry. The source of the improvement in efficiency was not explained nor substantiated with manufacturer specs within the program documentation. This steam savings was converted to natural gas savings using a conversion factor of 1,000 Btu/lb steam and a boiler efficiency of 82%.

Dryer savings were also claimed for this project, which are derived from an improvement in efficiency of the new dryers as measured in Btu/lbs water evaporated. The applicant's savings algorithm assumed that the baseline dryers consume 2,400 Btu/lb whereas the new dryers are stated to consume 1,755 Btu/lb. The source of the improvement in efficiency was not explained nor substantiated with manufacturer specs within the program documentation.

The applicant's savings algorithm (see Table 5) assumed that 0.55 lbs of water was contained in every lb of linen when it left the washer and was loaded into the dryer. This value remained constant for both the baseline and tunnel washer systems. In addition, the analysis assumes that all laundry coming out of the washers goes through a full dry cycle in the dryers.

None of the manufacturer cut sheets included in the project documentation verified the 1755 Btu/lbs water evaporated figure used in the analysis or the 0.35lbs steam/lbs laundry figure associated with the new equipment.

Using the adjusted production figures contained in the PIR we were unable to obtain the adjusted savings figures of 296,690 therms/year using the savings algorithm. Using the figures included in the program documentation we calculated savings of 270,830 therms/yr.

Table 5: Application Savings Algorithm

Application Savings Algorithm		
Baseline		
Machine capacity	2,540	lb
Number of shifts	3	shifts/day
Work hours per shift	6	hrs/shift
Total work hours	18	hrs/day
Number of days operating per year	350	
Annual operating hours	6,300	
Total pounds of laundry processed per day	45,714	lbs/day
Total pounds of laundry processed per hour	2,540	lbs/hr
Total pounds of laundry processed per year	16,000,000	lbs/yr
Baseline Energy Use		
Unit water use	2.5	gal/lb of laundry
Total water use	6,349	gal/hr
Unit steam use	1.5	lb steam/lb of laudry
Total steam use	3,810	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	46.5	therms/hr
Unit electricity use	205.0	kW
Unit electricity use per pound	0.081	
Unit water evaporated	0.45	lb of water/lb of laundry
Total water evaporated	1,143	lb of water/hr
Unit gas use	2,400	Btu/lb of water evaporated
Total gas energy for evaporation	27.4	therms/hr
Total baseline gas usage	73.9	therms/hr
Annual baseline gas usage	465,483	therms/yr
Installed Energy Use		
Unit water use	0.9	gal/lb of laundry
Total water use	2,286	gal/hr
Unit steam use	0.35	lb steam/lb of laudry
Total steam use	889	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	10.8	therms/hr
Unit electricity use	120.8	kW
Unit water evaporated	0.45	lb of water/lb of laundry
Total water evaporated	1,143	lb of water/hr
Unit gas use	1,755	Btu/lb of water evaporated
Total gas energy for evaporation	20.1	therms/hr
Total installed system gas usage	30.9	therms/hr
Annual baseline gas usage	194,653	therms/yr
Total gas savings	270,830	therms/yr

2.1.7. Evaluation Energy Savings Algorithms

During the site visit it became clear that the tunnel washer specified in the application was not of the same type as the installed model. As such, the washer specs included in the application did not apply to the installed equipment. The installed washer is a Lavatec LT70X09-BT capable of 150 lbs per load. Because the system is the same make and model as the tunnel washer that was installed in 2006, the performance specs from that system were used in this analysis.

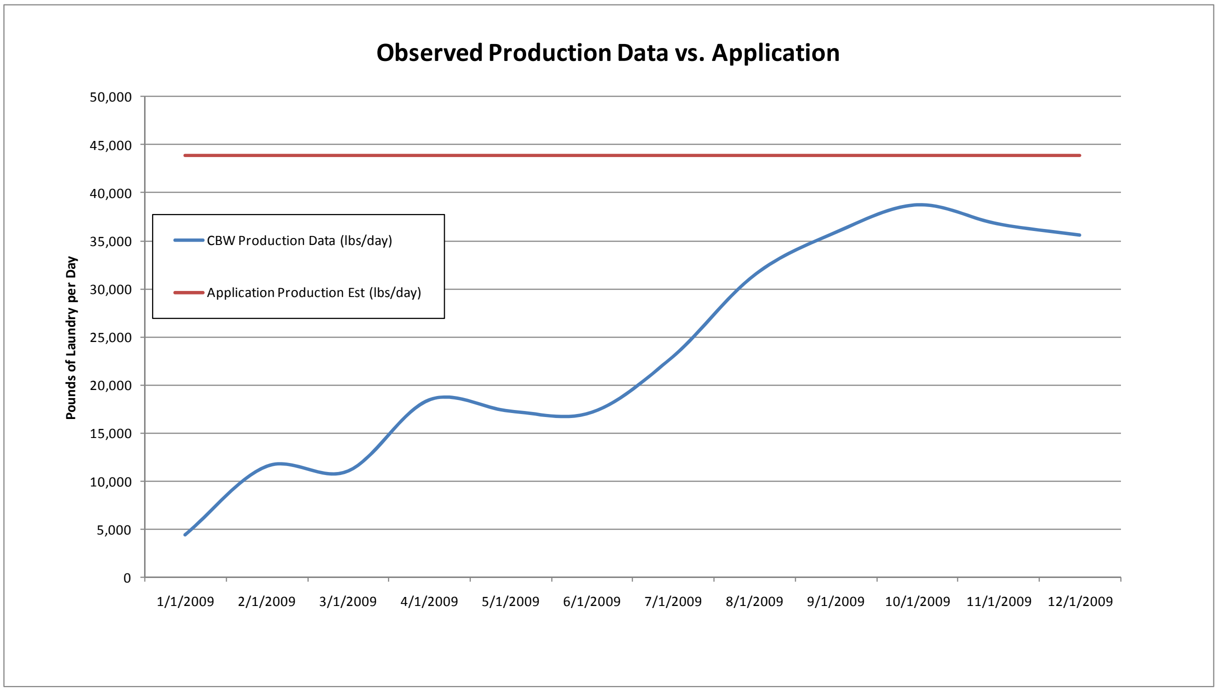
In general, the evaluators found the algorithms used in the application were appropriate in terms of methodology. However, we received little documentation or engineering data to support the numbers used in the calculations. The evaluators adjusted the algorithms to more appropriately account for the ways in which the laundry is processed through the drying process and to more accurately reflect the energy use of these machines. The following is a brief summary of the adjustments made, which are addressed in detail in this section:

- Boiler efficiency reduced to 78.2%
- Baseline washer steam usage reduced to 0.8 (lb steam/ lb laundry)
- Installed washer steam usage increased to 0.5 (lb steam/ lb laundry)
- Water evaporated in drying process reduced to:
    - Conditioned laundry: 0.2 (lb water/ lb laundry)
    - Full-dry laundry: 0.51 (lb water/ lb laundry)
- Installed dryer gas use increased to 2,000 (Btu/lb water evaporated)
- Logged production rates were used as the basis for annual process load

Laundry Production Data

The energy use and corresponding potential savings for all of the equipment in this project are directly proportional to the amount of laundry processed. Using the production data saved within the Lavatec tunnel washer control system, the total gas savings were calculated on a per-pound-of-dry-laundry-processed basis (therms/lb). The total amount of laundry processed in the Lavatec washer was significantly less than what was estimated in the application. The total system capacity of the new washer was much higher than the front-loading washers that were included in the original application. The application assumed an average daily production of 43,800 lbs. However in 2009 the system only averaged 23,451lbs per day. In the last 5 months of 2009, as the system was fully incorporated into the facility's production schedule, the washer averaged 35,700 lbs per day. Because of the large increase in production, savings were calculated as if this were a facility expansion, and they were based off of the installed system's monthly production and the increase in efficiency, on a per lbs of laundry processed level.

Figure 1: Tunnel Washer Production (as reported in Lavatec database)



Laundry Processing Split

Of the lightly soiled linen that the facility processes, there are two distinct drying patterns. Towels and linens that do not require ironing before they are returned to customers undergo a full drying cycle that removes all the water. This full-dry process lasts 20-30 minutes. Most of the linens (bed sheets and pillow cases) are ironed in the finishing process, which removes a significant amount of moisture from the linen, and are only “conditioned” in the Lavatec dryers for 2 to 5 minutes; just enough to break up the cake formed by the hydraulic press and remove some excess water.

On-site interviews and an analysis of the Lavatec database determined that the mix between these two processes was approximately 60% full-dry linen and 40% conditioned linen by weight. In addition, laundry was sampled and weighted at the three points in the drying process to determine the amount of water removed in each of the process steps.

These two processes needed to be analyzed separately so that the gas usage associated with drying the linen could be accurately characterized. Because no changes were made to the ironing process and the time to iron the same items from either the site’s batch or tunnel washers is reported to be the same, it was important not to assign any additional dryer savings to water which was removed in the finishing process.

Table 6: Full Dry/Conditioned Linen System Characteristics

Laundry Split	Wet	Conditioned	Full Dry
Production %	0%	40%	60%
Towel Weight	1.94	1.69	1.28
lbs water/# dry laundry	0.51	0.32	-

Installed Tunnel Washer System

The water consumption performance specs contained within the program documentation for the CBW tunnel washers were confirmed to be accurate in interviews with laundry design consultants and washer manufacturer representatives. However, the thermal energy specs for washer's steam usage as well as the dryer energy usage were determined to be inaccurate and as such the performance characteristics were adjusted. No manufacturer specifications could be found to verify the claimed 1,755 Btu/lb water evaporated in the program data, nor was it confirmed through discussions with manufacturers. Dryer logged data was unable to determine the total gas usage of the system because there was no observed difference in the combustion blower between high fire and low fire during the logging period. Market research and interviews with industry experts indicate that new highly efficient commercial tunnel washer systems average 2,000 Btu/lb water evaporated and so the analysis was changed to reflect this. The unit steam usage was adjusted down to 0.5 lb steam/lb laundry due to market research, interviews with industry experts, and logged data of the sites boilers. The table below presents the resource consumption values used in the evaluation calculations[4][5][6].

Table 7: Application CBW Performance Characteristics

Unit Water Use	1.0	gal/lb of laundry
Unit Steam Use	0.5	lbs steam/lb of laundry
Unit Electricity Use	0.068	kWh / lb of laundry
Unit Gas Use	2000	Btu/ lb of water evaporated

Savings Algorithm

A calculation method similar to the applicant's algorithm was used with the modified energy usage constants and a means to separate full-dry and conditioned linen (see Table 8). Natural gas savings was calculated for 1 pound of dry linen. Steam savings were calculated by multiplying the new steam usage constant by the total monthly pounds of laundry processed. Dryer savings were calculated using the measured moisture content levels and the observed laundry percentage that underwent full-dry and conditioning process.

[4] Bob Beddingfield, Laundry Consulting – Personal Interview, 2 Feb. 2010.

[5] Steve Wilbur, Braun Washer Technical Representative – Personal Interview, 3 Feb. 2010.

[6] Western State Design, - Personal Interview, 10 Feb. 2010.

The normalized savings (therms/lb) were multiplied by the monthly production from the Lavatec database and summed to determine the annual savings.

Table 8: Evaluation Savings Algorithm

Modified per Pound Dry Linen Analysis					
Baseline					
Machine capacity		1			lb
Number of loads			0.4	0.6	loads
Pounds of laundry processed			0.40	0.60	lbs
Boiler efficiency		78.2%			
Cross Check					
Number of machines		1			machines
Total pounds of laundry processed per hour			0.40	0.60	lbs
Baseline Energy Use					
Unit water use		2.5			gal/# laundry
Total water use			1.00	1.50	gal/# laundry
Unit steam use		0.8			lbs steam/# laundry
Total steam use			0.32	0.48	lbs steam/# laundry
Energy per pound of steam		1,000			Btu/lb
Energy use for steam			0.00409	0.00614	therms/# laundry
Unit water evaporated			0.20	0.51	lb of water/# laundry
Total water evaporated			0.0780	0.3073	lb of water/# laundry
Unit gas use		2,400			Btu/lb of water evaporated
Total gas energy for evaporation			0.0019	0.0074	therms/# laundry
Total baseline gas usage			0.0060	0.0135	therms/# laundry
	sum	**0.0195**			therms/# laundry
Installed Energy Use					
Unit water use		1.0			gal/# laundry
Total water use			0.40	0.60	gal/# laundry
Unit steam use		0.5			lb steam/# laundry
Total steam use			0.20	0.30	lb steam/# laundry
Energy per pound of steam		1,000			Btu/lb
Energy use for steam			0.00256	0.00384	therms/# laundry
Unit water evaporated			0.2	0.5	lb of water/# laundry
Total water evaporated			0.08	0.31	lb of water/# laundry
Unit gas use		2,000			Btu/lb of water evaporated
Total gas energy for evaporation			0.00156	0.00615	therms/# laundry
Total installed system gas usage			0.00412	0.00999	therms/# laundry
	sum	**0.0141**			therms/# laundry
Total Savings		**0.0054**			therms/# laundry

Boiler Efficiency

Combustion tests were performed on the four 49.9-hp Cyclotherm boilers on-site to determine the relationship between process steam savings and gas savings. All four boilers were well maintained and in full operation while combustion tests were performed. Table 9 summarizes the testing results. The application used the nameplate boiler efficiency of 82%; this was changed to 78.2% in our analysis to reflect the combustion tests results.

Table 9: Boiler Combustion Test Summary

	Efficiency (%)	Ex Air (%)	O2 (%)	CO2 (%)	CO ppm
Boiler 1	78.5%	41.0%	6.1%	8.4%	1
Boiler 2	78.7%	78.7%	4.9%	9.1%	0
Boiler 3	77.8%	52.0%	7.2%	7.7%	0
Boiler 4	77.6%	41.0%	6.1%	8.4%	2
Average	78.2%	53.2%	6.1%	8.4%	0.75

Evaluated Savings

The gas savings of the tunnel washing system per pound of laundry was 68% less than the application's calculations. This combined with the overestimation of the total system production led to a total energy savings realization rate of 17% in 2009.

Figure 2: Normalized Monthly Evaluated Savings

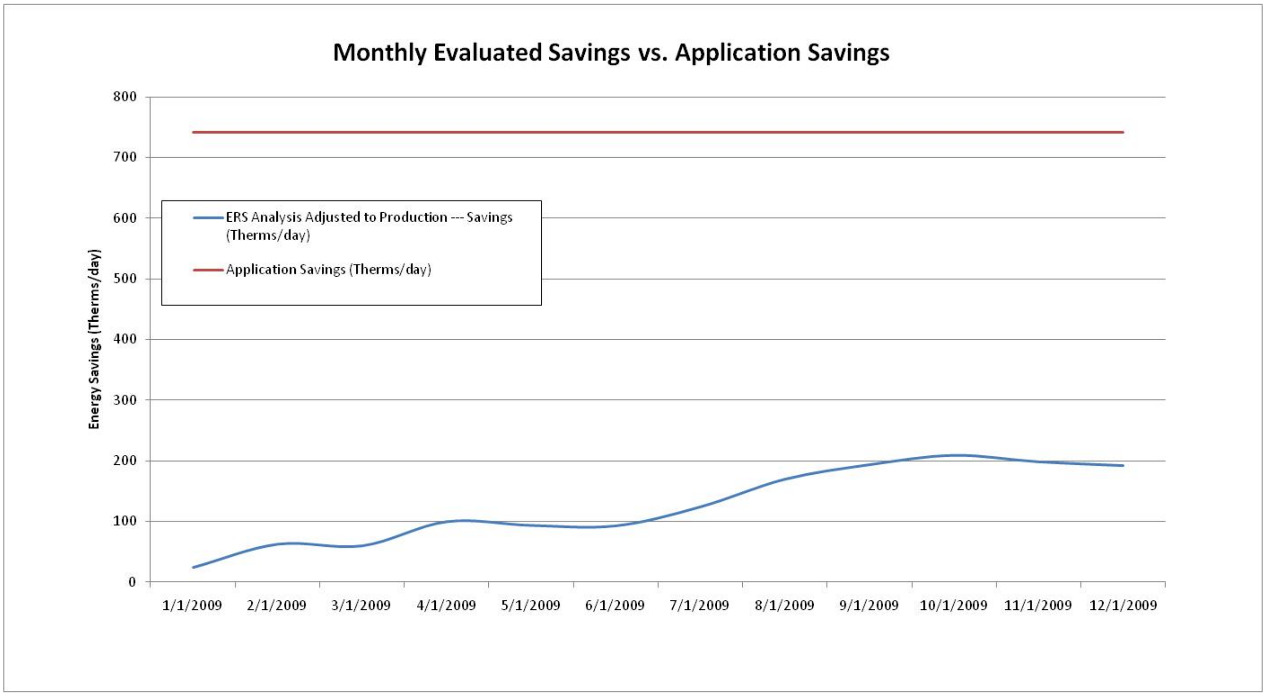


Table 10: Annual Realization Rates (2007-2009)

Year	Energy Savings Realization Rate	Production Realization Rate
2009	17%	53%

2.1.8. Data Measurement Method

Equipment monitored	Boilers	Washers
Parameter measured	Combustion efficiency	Performance data, operating hours, historical production
Measurement equipment	Combustion analyzer	Interview with the site staff & manufacturer, on-site observations, trended production data
Observation frequency	Spot measurement	N/A
Metering duration	N/A	N/A
Accuracy	± 1 % reading	N/A

2.1.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation and laundry system trend files, the analysis was conducted on an hourly basis. The hourly numbers were used to calculate the average monthly and annual values.

There is uncertainty regarding the unit energy use estimates. Both the baseline and installed energy use per unit production estimates rely in part on a combination of non-project specific data and expert interviews. While interviewers were confident in their performance estimates and had narrow estimates of the ranges for the values (nominally 5% to 10%), this introduces uncertainty. The experts did particularly assert that the application's baseline steam use per pound of laundry was well outside the plausible range.

Overall expected engineering accuracy including metering accuracy and uncertainties: 15%

2.1.11. Non-Energy Impacts

Tunnel washer systems have significant non-energy benefits beyond natural gas savings when compared to traditional open pocket systems. The four main sources of savings include electrical savings, reduced water consumption due to the technology's counter-flow design, reduced labor costs due to the automated transfer from washer to dryer, and reduced footprint in the industrial space.

Electrical Savings

Because the baseline efficiency system was no longer on-site, it was not available for electrical metering. Due to the lack of baseline electrical use data the evaluators choose to rely on an industry study which was able to perform full metering. ITRON completed a full electrical evaluation of a similar 3000lbs/hr tunnel washer system for the California Public Utilities Commission in 2008. It concluded that when compared to a new convention system the tunnel washer saved 55.9kW. The application which was reviewed in this CPUC evaluation also originally claimed an 80-90kw savings.

Year	kW Savings	Annual Washer Hrs	Average Electrical Rate ($/kwh)	Annual Savings (kWh)	Annual Savings ($)
2009	55.9	4600	$ 0.06	257,100	$ 14,700

Water Savings

Using the same per pound of linen processed method of calculating savings used described in Table 8 the water savings for this measure were calculated. The water usage specs for the baseline and installed technology were confirmed with industry experts and described in Tables 4 and 7.

Year	Water Savings (Gal)	Annual Savings @ $.008/gallon
2009	8,031,900	$ 64,300

Labor Savings

Because the tunnel washer automatically transfers linen from the washer to the extractor and finally to the dryer, the technology reduces the labor costs for the site. The machine is able to be operated by two workers, one to weigh and load the linen and another to unload the linen after it has finished the drying cycle. In conversations with the site contact and industry experts it was determined that a similar baseline technology system would require 1.5 additional Full Time Equivalents for a system of similar capacity.

Year	FTE Savings	Average Labor Cost per Hour	Annual Washer Hrs	Annual Savings
2009	1.5	18	4600	$ 124,200

Footprint Savings

The final non-energy benefit is the reduced footprint of the system when compared to similar conventional front loading systems. In addition to the smaller footprint of the machine, the automatic loading from the washer to the dryer eliminates the need for an overhead track system or paths for carts to move and manually transport linen from the washer to dryer. Average footprints for new open pocket and tunnel washing systems were determined and normalized to the capacity of the system installed at the evaluated site. Annual rent cost estimations were found through a survey of similar spaces in the Bronx.

Year	Footprint Savings (square ft)	Average Industrial Rent in Bronx ($/sq ft/yr)	Annual Savings
2009	800	16	$ 12,800

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The evaluated savings is lower than reported primarily because it used a higher baseline unit efficiency and a lower unit production rate.

Specifically, evaluators concluded that the application savings calculations overestimated the savings on a per pound of laundry processed basis by 64%. This was due to the fact that the baseline energy use per pound of laundry was overestimated and the installed equipment was not the same type that was specified in the application.

Because the new system only processed 52% of the annual laundry estimates contained in the application the measure resulted in a realization rate of 17%.

The slightly lower evaluation-measured boiler efficiency slightly increased savings, and splitting out the full-dry linen from the conditioned linen slightly reduced savings.

3.2. Deviations from Plan

The only major deviation from the original plan occurred when it was determined on-site that the Lavatec washers contained an internal database of every load of laundry that the machines had processed. This allowed the analysis for Measure 1 to be calculated on an hourly and monthly basis rather than the annual basis.

3.3. Recommendations for Program Designers & Implementers

For all future projects the baseline energy usage of the open pocket washers should be more closely scrutinized, as the figures used in this project as well as others we have evaluated have been significantly higher than our bill analysis and expert interviews indicate are plausible.

In addition, the PIR should have caught the fact that the installed equipment was not the same as what was specified in the original application and adjusted the performance specs of the installed system accordingly.

3.4. Customer Alert

None. The site contact was extremely helpful and more than willing to discuss energy efficiency opportunities.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	
Building predominant year of construction	

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/25/2010
Site visit date(s)	1/14/2010, 2/10/2010, 3/2/2010
Draft site report completion date	3/15/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF24

March 17, 2009

SUMMARY INFORMATION

Project ID	EF24
Program Being Evaluated	Existing Facilities
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial

Principal Site Contact	
Title	
Phone	
Email	

NYSERDA Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	
Phone	
Email	

Lead Evaluation Engineer	Shamus Cunningham
Report Author	Shamus Cunningham

1. PROJECT SUMMARY

The facility is a commercial laundry service that specializes in laundry services to hospitality industry. The facility operates two 6-hour shifts throughout the year.

The measure involved in replacing four existing conventional washers with a continuous batch washer.

1.1. Savings

Measure ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Continuous batch washer	Reported	0	0	30,336	$441,793
		Evaluated	n/a	n/a	0	
		Realization Rate	n/a	n/a	0%	

1.2. Measure Sampling

Since the project involved one measure at a single site, sampling was not necessary to evaluate the savings.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	20	$2,600	
On-site M&V	32	$4,160	
Analysis	36	$1,680	**Site Evaluation Cost / Incentive**
Report	34	$3,910	
Total	122	$15,350	3.4%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The new tunnel washer replaced four existing 700 lb Washex (M# 46110) washers. The washers operate twelve hours a day throughout the year (approximately 4,200 hours a year). The washer specifications are listed in Table 1:

Table 1: Application Baseline Performance Characteristics

Unit Water Use	2.5 gal/lb of laundry
Unit Steam Use	1.5 lbs steam/lb of laundry
Unit Electricity Use	212 kW
Unit Gas Use	2400 Btu/ lbs of water evaporated

The analysis worksheet assumed that four machines with a capacity of 1,200 lbs/hr were replaced by the new Lavatec system.

2.1.2. Evaluation Description of Baseline

This new tunnel washer did not represent a significant expansion of the site's lightly soiled laundry business. Interviews with the site contact confirmed that the monthly sales and production has not changed more than 5% in the past 5 years.

During the site visit five open pocket washers with capacities between 480 to 700 lbs were observed. The four Washex open pocket washing machines listed in the application were still on-site and functioning during the site visit. Of the five Washex units on-site three are still in working condition. The site contact described their daily operation as minimal as they were only being used for rewashing clean linen that had come into contact with the floor and for washing comforters.

In addition to the five Washex units, a second older Lavatec tunnel washer was on-site that was not mentioned in the original application. Interviews with site staff revealed that this unit's daily production time was significantly reduced with the installation of the new tunnel washer. This older tunnel washer, which used to operate continuously throughout the two 6-hour shifts, is now operated less than 3 hours per day. The old tunnel washer unit was of a smaller capacity and the new larger tunnel washer unit allows the site to operate fewer hours per day.

The evaluation baseline for this measure was a combination of the Washex open pocket units and the 20-year-old Lavatec tunnel washer both of which are now in minimal use due to the new equipment installation. According to site staff replacing the old tunnel washer with new batch washers was not an option they could reasonably consider due to space constraints and non-energy impacts such as washing production rates per employee.

2.1.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility's gas usage is not weather dependent. The facility's production data has shown consistent production between 2006 and 2010 with minimal seasonal variation.

2.1.4. Application Description of As-Built Equipment and Operation

The conventional washers were replaced by a single Lavatec LT90 tunnel washer. The tunnel washer (also known as continuous batch washer) has ten sections and each section can be configured to have different water temperatures and varying water levels. The laundry moves through each section of the machine where a different washing process occurs. Water is recycled in this machine with the cleanest water being used for the final rinse and the dirtiest water being used for the presoak stage. This counter-flow water reuse design accounts for the majority of the hot water savings. The tunnel uses direct steam injection in order to achieve the necessary water temperature setpoints in each of the fourteen sections. These setpoints are specified by the site's chemical provider. In order for the chemical reactions, which provide the cleaning power, to occur at a satisfactory rate, the cleaning process must achieve 160°F for a sustained period.

According to the project documentation and interviews with the site contact the tunnel washer is used for towels approximately two thirds of the time and for bed linen the rest of the time.

The installed tunnel washer performance characteristics as provided in the project documentation are listed in Table 2.

Table 2: Application CBW Performance Characteristics

Unit Water Use	1 gal/lb of laundry
Unit Steam Use	0.5 lb steam/lb of laundry
Unit Electricity Use	0.068 kWh /lb of laundry
Unit Dryer Gas Use	1,755 Btu/lb of water evaporated

As can be seen from Table 2, the measure installation also claimed electrical savings

Five 49.9-hp Cyclotherm Boilers (M#LPF60) generate steam for use in the process and have a nameplate efficiency of 79.7%. This nameplate efficiency was used in all of the application's savings calculations.

2.1.5. Measure Life

Specific measure life details are not available for the washers.

2.1.6. Applicant Energy Savings Algorithms

The energy savings reported in the original project documentation were calculated as follows:

The rate at which the laundry would be processed through the installed equipment was first obtained.

- A process rate of 4,750 lbs/hr was derived after determining the total capacity and loading rate of the new system (95% of the maximum nameplate process rate).
- The 4,750 lbs/hr was assumed to operate for 4,200 hours per year for an annual total of 19,950,000 lbs/year.

The conventional (baseline) and continuous (as-built) washer performance data (as described in sections above) was used to calculate the water and steam used for the different systems.

The measure's steam savings were calculated by multiplying the annual lbs of laundry processed by the difference in steam usage (lb steam/lb laundry), as described in section 2.1.2 and 2.1.4. The applicant's savings algorithm assumed that the baseline washers consume 1.5 lb steam/lb laundry whereas the new washers are stated to consume 0.5 lb steam/lb laundry. This steam savings was converted to natural gas savings using a conversion factor of 1,000 Btu/lb steam and a boiler efficiency of 79.7%.

Dryer savings were also claimed for this project, which are derived from an improvement in efficiency of the new dryers as measured in Btu/lbs water evaporated. The applicant's savings algorithm assumed that the baseline dryers consume 2,400 Btu/lb whereas the new dryers are stated to consume 1,755 Btu/lb.

The applicant's savings algorithm assumed that 0.55 lbs of water was contained in every lb of linen when it left the washer and was loaded into the dryer. This value remained constant for both the baseline and tunnel washer systems. In addition, the analysis assumes that all laundry coming out of the washers goes through a full dry cycle in the dryers.

Table 3: Application Savings Algorithm

Application Savings Algorithm		
Baseline		
Machine capacity	750	lb
Number of shifts	2	shifts/day
Work hours per shift	6	hrs/shift
Total work hours	12	hrs/day
Number of days operating per year	350	
Annual operating hours	4,200	
Total pounds of laundry processed per day	57,000	lbs/day
Total pounds of laundry processed per hour	4,750	lbs/hr
Total pounds of laundry processed per year	19,950,000	lbs/yr
Baseline Energy Use		
Unit water use	2.5	gal/lb of laundry
Total water use	11,875	gal/hr
Unit steam use	1.5	lb steam/lb of laudry
Total steam use	7,125	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	89.4	therms/hr
Unit electricity use	212.0	kW
Unit water evaporated	0.55	lb of water/lb of laundry
Total water evaporated	2,613	lb of water/hr
Unit gas use	2,400	Btu/lb of water evaporated
Total gas energy for evaporation	62.7	therms/hr
Total baseline gas usage	152.1	therms/hr
Annual baseline gas usage	638,811	therms/yr
Installed Energy Use		
Unit water use	1.0	gal/lb of laundry
Total water use	4,750	gal/hr
Unit steam use	0.5	lb steam/lb of laudry
Total steam use	2,375	lb steam/hr
Energy per pound of steam	1,000	Btu/lb
Energy use for steam	29.8	therms/hr
Unit electricity use	120.8	kW
Unit water evaporated	0.55	lb of water/lb of laundry
Total water evaporated	2,613	lb of water/hr
Unit gas use	1,755	Btu/lb of water evaporated
Total gas energy for evaporation	45.8	therms/hr
Total installed system gas usage	75.6	therms/hr
Annual baseline gas usage	344,282	therms/yr
Total gas savings	294,529	therms/yr

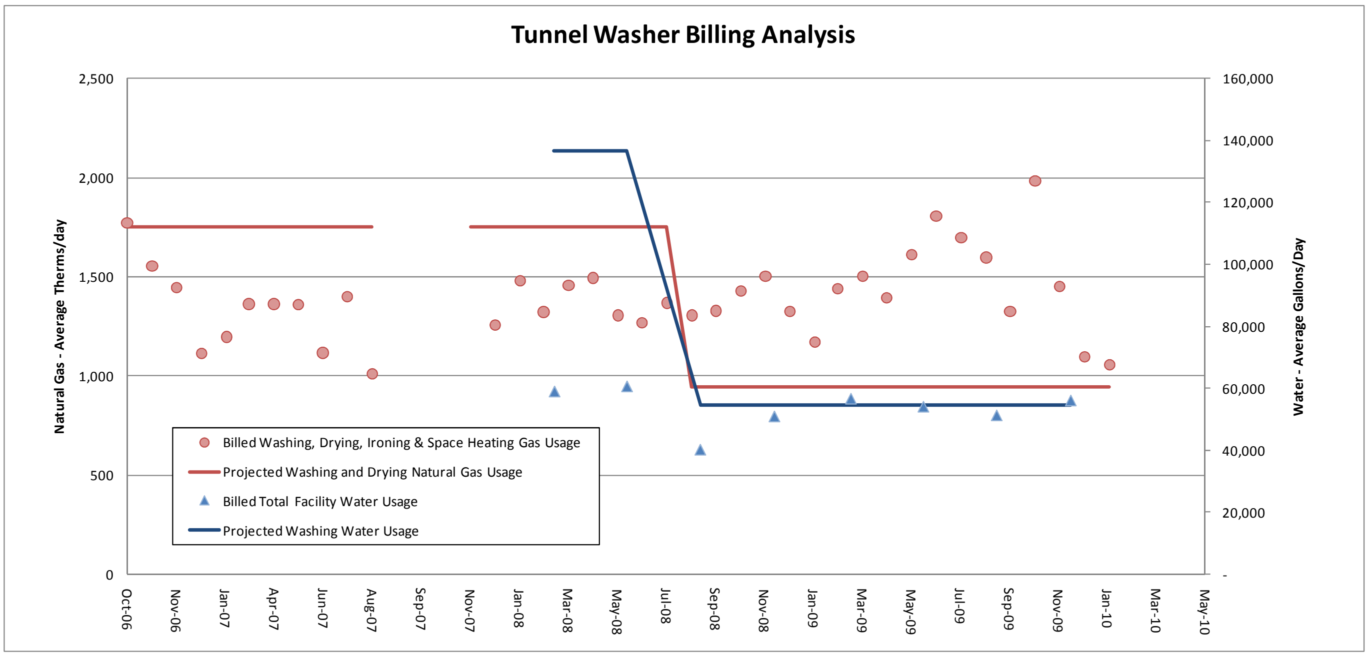
2.1.7. Evaluation Energy Savings Algorithms

The Lavatec tunnel washer that was installed at this location was not equipped with a built-in scale. As such, the system's database did not record the total amount of laundry that was processed.

Due to the uncertain proportion of laundry in the baseline case that was processed using the old tunnel washer vs. the Washex open pocket washers and the constant production of the entire facility, the evaluators deemed that a billing analysis was the best way forward.

Through interviews with the site contacts it was determined that no other natural gas efficiency projects had taken place since the installation of the new tunnel washer and that no additional equipment which uses natural gas was installed.

Table 4: Application Savings Algorithm



As can be seen in Table 4, there is no discernable difference in the monthly billed gas usage before and after the measure was installed. In the period between October of 2006 and July of 2008 in no single month did the billed gas usage reach the projected gas usage for the period. Furthermore, the projected gas usage only accounts for energy used in the washing and drying process; it does not account for the gas used in the ironing process as well as any other space heating gas usage.

Because the total gas usage of the building did not change, we concluded that the majority of the new tunnel washer's process load has displaced the old tunnel washer. As such, the laundry facility is probably operating similarly to the way it did before the measure was installed. If the washing and drying of the lightly soiled linen accounted for 90% of the total natural gas usage as has been observed in similar sites, the baseline gas usage was overestimated by 25%.

2.1.8. Data Measurement Method

Equipment monitored	Boilers	Washers
Parameter measured	Combustion efficiency	Performance data, operating hours, historical production
Measurement equipment	Combustion analyzer	Interview with the site staff & manufacturer, on-site observations, trended production data
Observation frequency	Spot measurement	N/A
Metering duration	N/A	N/A
Accuracy	± 1 % reading	N/A

2.1.9. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation and laundry system trend files, the analysis was conducted on an hourly basis. The hourly numbers were used to calculate the average monthly and annual values.

Overall expected engineering accuracy including metering accuracy and uncertainties: ±5%

2.1.11. Non-Energy Impacts

No non energy impacts occurred at this site.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Measure 1: Tunnel Washer

The baseline technology that was replaced by the new tunnel washer was not open pocket systems, but an older Lavatec tunnel washer. The baseline annual gas usage was overestimated by at least 25%.

3.2. Deviations from Plan

The major deviation from the original plan occurred when it was determined on-site that the new Lavatec washer had replaced not only the Washex open pocket washers but also an older tunnel washer, that replacing the old tunnel washers with batch washers was not a viable option, and that production levels had not substantially changed in the last 3 years. These three factors combined with the knowledge that reported savings were well over 40% of historical bills led us to change the methodology from the proposed engineering basis to a site-billing analysis basis.

3.3. Recommendations for Program Designers & Implementers

The baseline estimation of the processes gas usage was larger than the facility's total gas consumption. This could have been caught in the PIR or initial review. In addition, the presence of the 20-year-old tunnel washer should have been noted in the PIR and the operation of the installed equipment should have been verified to have displaced production capacity of the Washex machines as opposed to the older tunnel washer.

3.4. Customer Alert

None.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	–
Total building floor area affected by retrofit *(skip for process measures)*	n/a
Building predominant year of construction	n/a

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/20/2010
Site visit date(s)	1/27/2010
Draft site report completion date	3/30/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	EF2
Site Name	EF2
Project Close Date	10/12/2006
NYSERDA Program Component	SEC
Nexant Project Reviewer	Angela Patnode
Nexant Project Inspector	Angela Patnode
Inspection Date and Time	3/14/2006 @ 11:30 AM

Measure Description [1]	**High Efficiency Full-Size Convection Oven**	
	NYSERDA	**Nexant**
Oven Manufacturer	Duke	Duke
Oven Model Number	E-101-G	E-101-G
Oven Capacity, kBtu/hr	70	40
Capacity per Burner, kBtu/hr [2]		20
Hours of Use Per Year [3]	2496	4186
Baseline Unit Manufacturer		Garland
Baseline Unit Capacity, kBtu/hr [4]		40
Oven Cooking Energy Efficiency [5]	0.45	0.55
Baseline Unit Efficiency [6]	0.35	0.35
Oven Duty Cycle (%)	0.35	0.35
Baseline Energy, MMBtu	61	59
Proposed Energy, MMbtu	48	37
Gas MMBtu Savings [7]	13.9	21.3
Gross Realization Rate		153%

Inspection Notes	1. Customer replaced a Garland brand oven rated at 80,000 Btu/hr with a 40,000 Btu/hr oven after the original unit failed unexpectedly; customer feels the new unit performs the exact same work as the old unit. 2. Nexant verified manufacturer, model number, and rated input per burner from the nameplate on the unit; number of burners is not specified on the nameplate and not clearly discerned from visual inspection of the unit. It is likely the unit has two burners, based on the size of the unit. 3. Staff verified the oven is turned on from about 5:30 AM through 5:00 PM, seven days a week 4. The baseline unit capacity is reported based on information provided by site contact; for consistency, calculations are performed assuming both baseline and installed units have operating capacity of 40,000 Btu/hr input.
Review Notes	5. The unit efficiency is taken from memo by Mark Mayhew, referencing test documents supplied by the manufacturer; the test results are not included in the project file. 6. Baseline unit efficiency and duty cycle values are taken from the Gas Deemed Savings Database (references: Food Service Technology Center (Fischer Nickel), "Commercial Cooking Appliance Technology Assessment, Fall 2002. PG&E, PY2004/PY2005 Gas Workpaper, September 2003. Pacific Gas & Electric (PG&E) , "California Statewide Commercial Sector Natural Gas Energy) 7. NYSERDA reported savings are based on the following assumptions: 70 kBtu/hr capacity, 2496 operating hours per year, 35% duty cycle, 35% baseline efficiency, and 45% installed efficiency. Adjusted savings are higher than stipulated because installed unit efficiency is greater than stipulated installed efficiency and because run hours of the unit are greater than stipulated

ERS Review Notes	1. ERS corrected unit efficiency to be consistent with 55% efficiency published on EnergyStar website. 2. ERS assumed that baseline and proposed unit operated at the same capacity (40 kBtuh).

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF3

May 17, 2010

SUMMARY INFORMATION

Project ID	EF3
Program Being Evaluated	Enhanced Commerical Industrial Program
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial - Wholesale/Retail
Customer Business/Product	Function Hall

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	George Sorin Ioan
Report Author	George Sorin Ioan

1. PROJECT SUMMARY

The project consisted of the installation of three measures:

1. High Efficiency HVAC Unit
2. Dual-enthalpy economizer
3. Two programmable thermostats

The HVAC unit is rated at 15 tons and is equipped with one 400-MBtuh, 80% efficient gas heater and with one single-input enthalpy economizer. The project has been installed through the Enhanced Commercial Industrial Performance Tier I Program. The project documents do not provide details on the spaces served by the HVAC unit or the programmable thermostats.

The NYSERDA Buildings Portal shows that the electric savings associated with the high efficiency cooling and the economizer were funded through SBC and thus are excluded from the gas program evaluation.

The Luxaire DW15 gas heating system meets but does not exceed NYECCC code, so all gas savings are associated with measure #3.

The programmable thermostats were funded entirely with gas funds, so gas program evaluators have attributed associated electric impact to the gas program.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMbtu/yr)	Incentive Value ($)
3	Two programmable thermostats	Reported	0	0	33.67	$100
		Evaluated	4,207	0	131.8	-
		Realization Rate	na	na	391%	-

1.2. Measure Sampling

None.

1.3. Budget

Task	Hours	Cost Including Expenses	Site Evaluation Cost / Incentive
M&V Plan	6	$588	
On site M&V	11	$1,078	
Analysis	8	$784	
Report	4	$392	
Total	29	$2,842	$2,842/$100

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #3: Programmable Thermostats

The measure consisted of installation of two programmable thermostats in the function hall. The site contact indicated that the thermostats control the newly installed 15-ton and 10-ton RTUs.

2.1.1. Application Description of Baseline

The project documents do not indicate if the new thermostats replaced manual thermostats or broken programmable thermostats.

2.1.2. Evaluation Description of Baseline

The site contact indicated that before the measure was installed, the space temperature was controlled by manual thermostats. We considered manual thermostats with no setback capability as baseline. The baseline is provided by NYSERDA’s Deemed Savings Database V.12.

2.1.3. Seasonable Variability in Schedule and Production

The space heating system is operational only during the heating season.

2.1.4. Application Description of As-Built Equipment and Operation

The measure was installed through a prescriptive application. The post-retrofit system received incentives under measure CE14, which requires programmable thermostats (incentive is for each unit).

The project documents do not provide details on the post-retrofit equipment operation.

2.1.5. Applicant Energy Savings Algorithms

Savings were calculated from deemed values that were assigned to the prescriptive thermostat measure.

2.1.6. Evaluation Energy Savings Algorithms

This started as a verification-level site and was upgraded to basic.

In summary, the overall analysis savings analysis approach was to use post-retrofit monthly billing data to determine energy use as a function of average inside-outside temperature difference (separate for heating & cooling modes), and then to adjust this average temperature difference due to lack of a programmable thermostat setback schedule to estimate pre-retrofit energy use. Because analysis indicated the building displayed abnormal energy use patterns for the region—nearly 500% of typical heating energy use per square foot—evaluators also completed traditional bin-based engineering building simulation model to support the regression-based results.

Evaluators verified installation on-site. The measure was installed as stated in the application. During the site visit evaluators observed that the thermostats were in heating mode and set to temporary hold 55°F and 54°F in the function hall, while the actual space temperature shown on their screen was 65°F and 60°F, respectively. The site contact indicated that only when the main function hall is occupied with customers, the thermostats are reset to maintain 70°F. The site contact also indicated that they had manually applied temperature setbacks with the old thermostats, but could not recall the setback values. Evaluators have estimated the pre-measure implementation heating temperature setback to be 5°F.

The site contact could not provide us information on the typical operating hours due to discomfort with estimating occupancy for what is an erratically scheduled space. When we calculated the savings estimates, we considered that the space is occupied 7 days per week, 6 hours per day on weekdays, and 12 hours per day on weekends, and that the setback temperature is 60°F based on the contact's description of the range of conditions. The occupied temperature setpoint was 70°F. We estimated that the space is occupied on average, by 80 people, or at about one third of its design capacity (240 people).

Evaluators analyzed the post-installation gas use to estimate the heating system gas usage. Then we normalized the heating system gas usage based on TMY3 weather data for White Plains Westchester County.

Evaluators regressed the normalized heating gas use against the difference between TMY3 monthly average outdoor temperature and post-retrofit space average setpoint temperature. We used the regression coefficients to estimate the heating system gas use in the pre-retrofit and post-retrofit systems. We estimated the gas savings by subtracting the post-retrofit system gas use from the pre-retrofit system gas use.

We estimated the electric energy impacts associated with this measure with an energy model. We reconciled the energy model with provided gas bills.

2.1.7. Data Measurement Method

The installed thermostats control the space temperature in the main function hall. They were set to heat and programmed to temporary hold 55°F and 54°F, while the actual space temperature shown on their screen was 65°F and 60°F, respectively. Although the outdoor temperature was 37°F, because of this setback the RTUs were off. The photo below shows the status of one of the two thermostats.

Equipment inspected	Programmable thermostat	Programmable thermostat
Operating mode	Heating - hold	Heating - hold
Temperature setpoint	55°F	54°F
Observation frequency	N/A	N/A
Metering duration	N/A	N/A
Accuracy	N/A	N/A

2.1.8. Site Sampling Strategy

There is no sampling associated with this measure.

2.1.9. Uncertainties

The project documents do not provide details on the baseline and as-built systems operation. Pre-measure implementation utility bills were also unavailable. The site contact was not able to provide us details on the function hall schedule and occupancy or exact pre- and post-measure implementation temperature setpoints and schedules. Evaluators estimated the space occupancy based on information provided by the site contact and estimates for similar facilities. The project documents do not provide any information on the space heating load. Overall uncertainty is high given the difficulty in estimating the occupancy schedule and potential manual overrides to settings for this type of application.

This uncertainty was compounded by the fact that model analysis revealed that the facility used over four times the typical annual heating energy use per square foot for building in this climate zone. In order to calibrate the engineering model to bill data engineers had to incorporate low wall R-values (R-wall = 10 and R-roof = 15) and abnormally high infiltration rates (4.8 air changes/hr). Evaluators were not able to measure these parameters. The increase in these variables was consistent with the steep slope of the regression line between monthly gas use and average outdoor air temperature.

The evaluated savings represent 17% of the pre-retrofit heating system gas use and 10% of the total facility gas use, which is within a reasonable range for a setback thermostat measure.

2.1.10. Non-Energy Impacts

There were no non-energy impacts (i.e., operations and maintenance costs or water savings) associated with this project.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The high realization rate of 391% is attributable to several factors:

1. The deemed savings for a programmable thermostat is likely based on controlling a unit with less than 200 kBtu/hr capacity, the average amount controlled by each thermostat. All else being equal, a thermostat controlling a large unit will save more than a thermostat controlling a small unit.
2. The analysis revealed that the facility runs these units 2,000 full load hours per year, more than is typical and more than the thermostat deemed savings calculations likely assume. We believe this is because of poor insulation and/or excessive infiltration or ventilation, resulting in a higher load at all times. More operation means more savings potential.
3. While data quality on the setback schedule and prior manual schedule is limited, we believe that the nature of the business, special events, allows facility managers to be more aggressive with their programmable thermostats setback schedules than a typical home or office, allowing additional savings compared to the deemed values.

3.2. Deviations from Plan

Evaluators initially only inspected the site to verify installation and later upgraded the analysis quality by performing bill analysis and collecting additional data to perform modeling and analyze site-specific savings analysis.

3.3. Recommendations for Program Designers & Implementers

The evaluation would be more effective if a description of the baseline system affected these types of measures was provided.

3.4. Customer Alert

The site contact was reluctant to provide the facility schedule stating that the business was bad in 2009 and that due to the nature of the business he could not estimate how many hours the facility operates.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	Approximately 3,600 ft^2
Building predominant year of construction	1980

3.6. Evaluation Dates

Assignment date	-
Plan approval date	-
Site visit date(s)	2/9/2010
Draft site report completion date	3/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

Site-Specific Measurement and Verification Plan

EF4

April 21, 2010

Project ID	EF4		
Program Being Evaluated	Commercial/Industrial Performance Program (ECIPP)		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Education K-12		
Customer Business/Product	Education		

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone			
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	George Sorin Ioan
Plan Author	George Sorin Ioan

1. PROJECT SUMMARY

The project consisted of replacement of 204 steam traps in zones 8 and 9 of the steam distribution system.

1.1. Savings

The project measures have been assessed against prescriptive criteria and no savings have been calculated.

Meas. ID	Measure Name		Oil Savings (MMBtu/yr)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Replace and Repair Steam Traps	Reported	0	42.8	$3,604.98
		Evaluated	201	761	-
		Realization Rate	Na	1,777%	-

1.2. Measure Sampling

No measure sampling was necessary for this project. All measures were evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	Site Evaluation Cost / Incentive
M&V plan	3	$294	
On site M&V	11	$1,078	
Analysis	6	$588	
Report	4	$392	
Total	24	$2,352	65%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #1: Steam Traps Replacement

The measure consisted of a combination of repairing, rebuilding, and replacing 204 steam traps on the steam distribution system.

2.1.1. Application Description of Baseline

The project documents indicate the project is a retrofit but does not provide much detail on the pre-retrofit system. The documents indicate that the pre-retrofit steam traps were ineffective in zones 1, 2, and 8 and that the steam traps in zones 8 and 9 have been repaired or replaced.

2.1.2. Evaluation Description of Baseline

According to the site contact, a steam trap survey was performed to identify the failed steam traps. The large majority of the steam traps in zones eight and nine of the space heating distribution system had failed. The site contact could not give an approximation on the traps failed position.

2.1.3. Seasonable Variability in Schedule and Production

The space heating system is operational only during the heating season.

2.1.4. Application Description of As-Built Equipment and Operation

The measure consisting of steam traps repair and steam traps replacement was funded through a prescriptive application, labeled as measure type CE32. The project documents do not provide details on the post-retrofit equipment operation.

2.1.5. Applicant Energy Savings Algorithms

Savings were calculated from deemed values that were assigned to the prescriptive steam traps replacement measure.

2.1.6. Evaluation Energy Savings Algorithms

The intention of this evaluation was to verify that the measure had been installed and to provide an estimate of the gas impacts realized by implementing the measure consisting of steam trap repair and steam trap replacement. The site contact provided a list with model numbers and quantities of the traps that had been repaired and with the traps that had been replaced. Based on the information collected during the site visit, we verified that the measure was properly implemented and operating as expected.

The space heating system is supplied with 7-psig steam by two dual fuel (#4 fuel oil and natural gas) boilers. The boilers are old and evaluators were not able to identify the boiler efficiency during site visits and conversations with site staff. According to the site contact the boilers have outside temperature reset controls.

The steam boilers can be fueled by natural gas or #4 fuel oil. The site contact informed us that they switch fuels based on the price per therm. When we visited the site, the boilers were fueled by natural gas.

The site contact indicated that the school occupancy did not change from the pre- to post-measure implementation period and that they have not installed any other energy efficiency measures at the school since the project was installed.

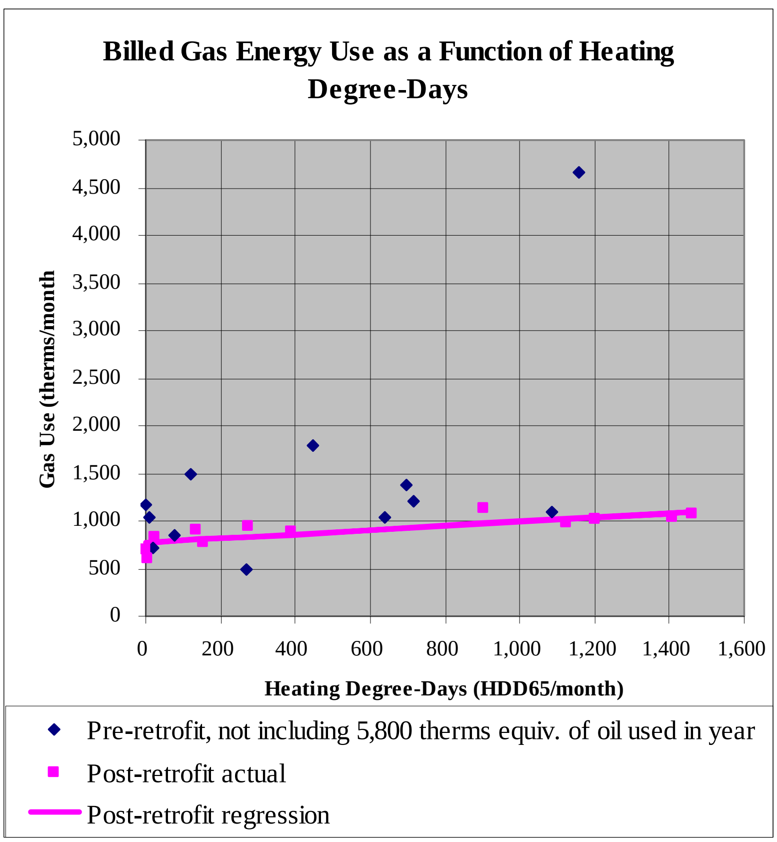
The steam traps were replaced between January and April 2008. The site contact provided us with the heating gas bills and #4 fuel use for the period starting in July 2006 and ending in July 2009. The energy use is grouped by school year (July – July). We considered the 2006-2007 school year gas usage as baseline and the 2008-2009 school year gas as post-installation energy use.

The gas bill for the interval between January 12, 2006 and March 24, 2006 shows a very large quantity of gas used for heating and the site contact could not indicate the reason for such high gas usage. We estimated that those months' usage is not representative of the heating load in the facility, and we excluded the abnormal portion from the analysis.

For 2006-2007 school year, based on actual weather data for Westchester County Airport, we estimated the heating degree days. The site contact indicated that besides the natural gas, 4,000-gallon of #4 fuel oil was used for heating during 2006-2007 school year. Because we could not estimate which months the oil was used, regression analysis of the pre-retrofit data was not possible and we simply computed annual Btus and HDD_{65}.

For 2008-2009 school year we performed monthly regression analysis using actual weather data from the local airport, and then projected energy use during the 2006-2007 and TMY weather conditions. Figure 1 shows the results.

Figure 1: Monthly Energy Use



We estimated the heating gas savings normalized to 2006-2007 weather data using the 2008-2009 regression and the 2006-2007 annual data, then adjusted the savings to TMY conditions.

Finally, we allocated the energy savings between gas and oil using the average of gas-oil proportions for the 2 known years.

The evaluated savings is considerably higher than the reported, more than 2000% realization rate on a total Btu basis. For that reason we also performed engineering analysis of the savings as a cross-check, which was not part of the original plan. The key inputs and calculations are shown in the table below. The formulas are according to the units shown.

Saturated steam @ 7 psig enthalpy			1158	Btu/lb
Makeup water @ 50F enthalpy			23	Btu/lb
Steam leak rate for 3/64" orifice with 0.72 discharge coeff.			2.0	lb/hr
Boiler efficiency			80%	
Boiler excess energy use			2.8	kBtu/hr/leaking trap
Heating season start	1-Dec			
Heating season end	15-Apr			
# Days	135	@ 24 hr/day =	3,240	hr/yr
Number of leaking traps repaired			204	
Savings			1,875	MMBtu/yr

As the last line of table illustrates, engineering-based savings estimates support relatively high savings, even higher than the bill analysis approach found.

Because of the degree of assumption required for the engineering approach, especially on steam leak rate, and because the savings is such a large percentage of the billed use—almost 50%--the evaluation relies solely on the bill analysis for evaluated results and uses the engineering calculations solely to give us confidence in the high realization rate.

2.1.7. Data Measurement Method

The site contact showed us the zones in which the steam traps had been repaired or replaced. We were able to get access to the space heating pipes in the gymnasium but the heating was off during the site visit. For this reason, we were able to use the ultrasonic gun to test the steam traps.

2.1.8. Site Sampling Strategy

Most of the steam traps have been installed in classrooms close to the radiators. The radiators in the classrooms were not accessible during our site visit as school was in session. We inspected steam traps installed in the gymnasium, in the library storage room, and in the hallway.

2.1.9. Uncertainties

The project documents do not provide details on the baseline system and as-built systems operation. We do not have details on the replaced steam traps failure position.

The facility uses gas and #4 fuel for space heating. The site contact indicated that the decision for switching between gas and #4 fuel is based on the cost difference and that they purchase the less expensive fuel at the time fuel is needed. The site contact indicated that on top of the natural gas, 4,000 gallons of #4 fuel were used for heating during 2006-2007 school year, while only natural gas was used in 2008-2009 school year.

2.1.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

NYSERDA reported 42.8 MMBtu/year in gas savings for this measure. Based on the billing analysis we estimated savings of 963 MMBu/year, 21% of which is in the form of oil and 80% in gas.

The reported savings appears to be based on a deemed savings 0.21 MMBtu/yr/trap. The evaluated savings from bill analysis found 4.7 MMBtu/yr/trap savings. Evaluators compared the results with other engineering sources. One historically reliable and unbiased source, the federal ITP program, provides a good source of steam loss rates for steam trap orifices of different sizes and steam system pressures (http://www1.eere.energy.gov/industry/bestpractices/pdfs/steam1_traps.pdf). Using that data for a low pressure system and 3,000 hr/yr of leaks to estimate annual loss (our number not theirs), the comparable annual loss is:

Trap Orifice Dia., inches	Steam Loss, lb/hr	MMBtu/yr / leaking trap
1/32	0.85	2.9
1/16	3.4	11.6
1/8	13.7	46.9
3/16	30.7	105.1

This suggests that the evaluated savings is, if anything, low and that NYSERDA may want to reconsider the deemed savings value currently in use.

3.2. Deviations from Plan

The initial verification was upgraded to bill analysis and then, due to the dramatic variation from reported savings, upgraded further and engineering analysis was added for comparison.

3.3. Recommendations for Program Designers & Implementers

Re-evaluate the steam trap deemed savings value.

3.4. Customer Alert

The site contact tried to do his best to provide the information we requested.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	Zone 8 – physical education area, locker rooms, gymnasium, offices, bathrooms Zone 9 – nine classrooms, media center
Building predominant year of construction	The building was built around 1930 with an additional four story wing added in 1992.

3.6. Evaluation Dates

Assignment date	
Plan approval date	
Site visit date(s)	2/24/2010
Draft site report completion date	3/17/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF5

April 19, 2010

SUMMARY INFORMATION

Project ID	EF5		
Program Being Evaluated	Existing Facilities Program		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Hospitality		
Customer Business/Product	Restaurant		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Chris Zimbelman
Report Author	Chris Zimbelman

1. PROJECT SUMMARY

This measure involved the replacement of a commercial conveyor style kitchen broiler with a new flexible batch broiler.

1.1. Savings

Meas. ID	Measure Name		Electricity Savings (kWh/yr)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Installation of new batch broiler	Reported	0	66.1	$500
		Evaluated	4,190	185.8	-
		Realization Rate	n/a	283%	-

1.2. Measure Sampling

Measure sampling was not necessary. All the equipment included in the project was evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	3	$318	
On site M&V	4	$424	
Analysis	6	$636	**Site Evaluation Cost / Incentive**
Report	4	$424	
Total	17	$1,802	$1,802/$500

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #1: New Flexible Batch Broiler

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

This was the replacement of a conveyor style broiler without burner cycling, with a flexible batch style broiler that contains an enclosed cooking chamber and burner cycling. The deemed savings for this measure were reported by NYSERDA using a pre-determined baseline of a broiler with 15% cooking efficiency and 2,496 annual operating hours.

2.1.2. Evaluation Description of Baseline

The baseline used for this evaluation was the broiler that was installed prior to the flexible batch broiler, which was a Nieco 950 conveyor broiler. During the interview the site contact verified that the prior boiler was still functioning at the time of replacement and that indeed it was a constant-firing model.

2.1.3. Seasonable Variability in Schedule and Production

Broiler operation fluctuates within the operating hours of the restaurant, with peak hours happening during meal times. Restaurant operation is relatively constant throughout the year.

2.1.4. Application Description of As-Built Equipment and Operation

One Duke Flexible Batch Broiler was installed at the restaurant. This broiler utilizes an enclosed cooking chamber to produce product. Rather than running continuously as the conveyor broiler did, this broiler uses thermostatic control to cycle the burner on and off to control to a temperature setpoint, which reduces energy use during non-cooking periods.

2.1.5. Applicant Energy Savings Algorithms

Measure impacts were determined from deemed savings values, meaning the savings were based on a predetermined therm/unit basis rather than actual energy savings for the installed equipment. Savings estimations were based on conveyor boilers with a baseline cooking efficiency of 15% requiring 53 kBtu/hr gas input and a proposed cooking efficiency of 30% along with 2,496 annual operating hours. Total reported savings were 66.1 MMBtu or **661 therms**.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators used information obtained at our site visit, along with published information on the baseline and proposed broilers to calculate the impact of the installation of the new Duke Flexible Batch Broiler.

Energy savings for this measure are directly related to the operational profile of the restaurant. This is due to the fact that a large part of the energy savings is due to the burner cycling instead of running continuously during off-peak times. In order to account for this, evaluators created an hourly weekday and weekend day profile of the restaurant based on information collected during site visits. These profiles accounted for the number of hours per day when the restaurant was closed (broilers off), the number of off-peak cooking hours per day, and the number of on-peak cooking hours per day. The combined weekly profile for this restaurant was as follows:

Table 1: Restaurant Operating Profile

Restaurant Weekly Profile	
Off-peak hours/week	74
On-peak hours/week	52
Closed hours/week	42
Total hours/week	168

Using this profile, along with information obtained from a published Food Service Technology Center study[1] on these batch broilers, evaluators calculated energy use for the baseline and proposed broilers. The report published the energy input rates (Btu/hr) for both the baseline and proposed broilers in “preheat,” “idle,” and “cooking” modes for the same broiler models removed and installed in this project. Evaluators used these values along with the restaurant cooking schedule to calculate annual energy use for both the baseline and proposed cases. We used the “idle” energy rate along with off-peak hours and the “cooking” energy input rate with on-peak hours. A summary of this calculation can be seen below:

Weekly Gas Use (Btu/week) = **off-peak hours** (hours/week) x **broiler idle energy rate** (Btu/hr) + **on-peak hours** (hours/week) x **broiler “cooking” energy input** (Btu/hr)

Table 2 below shows a summary of the calculated energy use for the baseline and installed broilers.

[1] *PGE Foodservice Equipment Workpapers, Gas Equipment, Pilot Measure 3: Flexible Batch Broiler-Gas, Measure Code: F152,* August 2007. This workpaper cites an FSTC study that compared energy use of these exact two broilers. For comparison, the results from that study found 1,438 therms/year in savings using 15-hour days.

Table 2: Energy Use Summary

Energy Use Summary	Nieco 950 Conveyor Broiler	Duke Broiler with Catalyst
Gas preheat energy (Btu)	19,600	22,980
Gas idle energy rate (Btu/hr)	89,500	67,250
Gas cooking energy rate (Btu/hr)	99,400	61,900
Weekly energy use (MMBtu/week)	11.93	8.36
Annual energy use (MMBtu/year)	620	435
Annual energy use (therms/year)	6,203	4,345
Annual energy savings (therms/year)	**-**	**1,858**

The annual energy savings calculated for this measure were 1,858 therms/year. This yields a gas realization rate of 283%.

The broiler manufacturer also estimates electricity savings associated with the upgrade of 4,190 kWh/yr due to reduced electricity use by the broiler. This estimate is based on an online manufacturer's savings estimate tool that allows inputs and takes into account the annual operating hours of the site.

In theory there is additional benefit in the form of reduced ventilation requirements and reduced heat gain but for this retrofit application evaluators believe such associated savings are unlikely. While some of the heat is radiated to other solids, most of the heat is exhausted, air conditioning in the kitchen is indirect, and the ventilation-hood fan speed was not adjusted downward in response to the new broiler's installation.

2.1.7. Data Measurement

Interview, inspect, and perform spot measurements as needed to:

- Verify measure installation
- Collect nameplate data
- Ask if equipment is operating properly
- Verify values of important variables
- Verify broiler is natural gas fired
- Collect operating hours and estimated production quantities

Variable	Deemed	Evaluation Inspection	Reasonable Long Term Range
Annual operating hours	2,496 hrs	6,552 hrs (3,848 off-peak hrs) (2,704 on-peak hrs)	6,552 hrs (3,848 off-peak hrs) (2,704 on-peak hrs)
Broiler efficiency	30%	n/a	n/a
Unloaded gas demand	n/a	67,250	67,250
Loaded gas demand	n/a	61,900	61,900

2.1.8. Site Sampling Strategy

Sampling is not required for this measure.

2.1.9. Uncertainties

Uncertainties arise due to multiple factors:

- The numbers used in this analysis are based on a performance test performed by an outside source rather than actual measurements taken by the evaluators. The results have been tailored to site-reported schedule.
- Actual on-peak and off-peak cooking times vary depending on number of customers eating at the restaurant. These numbers were estimated by the evaluators.
- There is a high degree of uncertainty associated with the electric savings. While the claimed premise is technologically valid, the quantitative estimate in this report relies solely on calculations from an unvetted manufacturer’s savings tool.

2.1.10. Non-Energy Impacts

The manufacturer claims the product reduces cleaning time by 25 to 30 minutes per day, which at a fully burdened labor rate of $10/hour, is worth $1,532/year. We were unable to verify this information for the facility; however discussions with similar facilities in the New York City area that installed the same measure indicated that the manufacturer claimed cleaning time savings were accurate.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The reasons for deviation are as follows:

- Deemed savings values are determined based on typical broiler operations and efficiencies and are not necessarily specific to the site. Due to this fact, the savings values reported were not representative of what the real impact at this site would be.
- The savings calculations performed in this evaluation used information that was relevant to the actual baseline and proposed broilers and real restaurant operating hours instead of generic measure values.
    - Annual operating hours were 6,552 instead of 2,496.
    - The deemed broiler, existing and proposed, was 40% smaller than the installed units.
    - The deemed broiler, existing and proposed, ran 7 FLH/day compared to the installed 18 FLH per day.

3.2. Deviations from Plan

There were no deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend requiring that the cooking efficiency be listed on product literature or on the specifications submitted with the applications.

3.4. Customer Alert

The store manager was helpful in showing us the installed broiler and discussing its operation.

3.5. Contextual Data

Not applicable for verification sites.

3.6. Evaluation Dates

Assignment date	n/a
Plan approval date	n/a
Site visit date(s)	3/9/10
Draft site report completion date	3/19/10

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF6

April 19, 2010

SUMMARY INFORMATION

Project ID	EF6		
Program Being Evaluated	Existing Facilities Program		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Hospitality		
Customer Business/Product	Restaurant		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Chris Zimbelman
Report Author	Chris Zimbelman

1. PROJECT SUMMARY

This measure involved the replacement of a commercial conveyor style kitchen broiler with a new flexible batch broiler.

1.1. Savings

Meas. ID	Measure Name		Electricity Savings (kWh/yr)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Installation of new batch broiler	Reported	0	66.1	$500
		Evaluated	4,893	224.6	-
		Realization Rate	n/a	340%	-

1.2. Measure Sampling

Measure sampling was not necessary. All the equipment included in the project was evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	3	$318	
On site M&V	4	$424	
Analysis	6	$636	**Site Evaluation Cost / Incentive**
Report	4	$424	
Total	17	$1,802	$1,802/$500

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #1: New Flexible Batch Broiler

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

This was the replacement of a conveyor style broiler without burner cycling, with a flexible batch style broiler that contains an enclosed cooking chamber and burner cycling. The deemed savings for this measure were reported by NYSERDA using a pre-determined baseline of a broiler with 15% cooking efficiency and 2,496 annual operating hours.

2.1.2. Evaluation Description of Baseline

The baseline used for this evaluation was the broiler that was installed prior to the flexible batch broiler, which was a Nieco 950 conveyor broiler. During the interview the site contact verified that the prior boiler was still functioning at the time of replacement and that indeed it was a constant-firing model.

2.1.3. Seasonable Variability in Schedule and Production

Broiler operation fluctuates within the operating hours of the restaurant, with peak hours happening during meal times. Restaurant operation is relatively constant throughout the year.

2.1.4. Application Description of As-Built Equipment and Operation

One Duke Flexible Batch Broiler was installed at the restaurant. This broiler utilizes an enclosed cooking chamber to produce product. Rather than running continuously as the conveyor broiler did, this broiler uses thermostatic control to cycle the burner on and off to control to a temperature setpoint, which reduces energy use during non-cooking periods.

2.1.5. Applicant Energy Savings Algorithms

Measure impacts were determined from deemed savings values, meaning the savings were based on a predetermined therm/unit basis rather than actual energy savings for the installed equipment. Savings estimations were based on conveyor boilers with a baseline cooking efficiency of 15% requiring 53 kBtu/hr gas input and a proposed cooking efficiency of 30% along with 2,496 annual operating hours. Total reported savings were 66.1 MMBtu or **661 therms**.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators used information obtained at our site visit, along with published information on the baseline and proposed broilers to calculate the impact of the installation of the new Duke Flexible Batch Broiler.

Energy savings for this measure are directly related to the operational profile of the restaurant. This is due to the fact that a large part of the energy savings is due to the burner cycling instead of running continuously during off-peak times. In order to account for this, evaluators created an hourly weekday and weekend day profile of the restaurant based on information collected during site visits. These profiles accounted for the number of hours per day when the restaurant was closed (broilers off), the number of off-peak cooking hours per day, and the number of on-peak cooking hours per day. The combined weekly profile for this restaurant was as follows:

Table 1: Restaurant Operating Profile

Restaurant Weekly Profile	
Off-peak hours/week	78
On-peak hours/week	69
Closed hours/week	21
Total hours/week	168

Using this profile, along with information obtained from a published Food Service Technology Center study[1] on these batch broilers, evaluators calculated energy use for the baseline and proposed broilers. The report published the energy input rates (Btu/hr) for both the baseline and proposed broilers in "preheat," "idle," and "cooking" modes for the same broiler models removed and installed in this project. Evaluators used these values along with the restaurant cooking schedule to calculate annual energy use for both the baseline and proposed cases. We used the "idle" energy rate along with off-peak hours and the "cooking" energy input rate with on-peak hours. A summary of this calculation can be seen below:

Weekly Gas Use (Btu/week) = **off-peak hours** (hours/week) x **broiler idle energy rate** (Btu/hr) + **on-peak hours** (hours/week) x **broiler "cooking" energy input** (Btu/hr)

Table 2 below shows a summary of the calculated energy use for the baseline and installed broilers.

[1] *PGE Foodservice Equipment Workpapers, Gas Equipment, Pilot Measure 3: Flexible Batch Broiler-Gas, Measure Code: F152,* August 2007. This workpaper cites an FSTC study that compared energy use of these exact two broilers. For comparison, the results from that study found 1,438 therms/year in savings using 15-hour days.

Table 2: Energy Use Summary

Energy Use Summary	Conveyor Broiler	Duke Broiler with Catalyst
Gas preheat energy (Btu)	19,600	22,980
Gas idle energy rate (Btu/hr)	89,500	67,250
Gas cooking-energy rate (Btu/hr)	99,400	61,900
Weekly energy use (MMBtu/week)	13.86	9.54
Annual energy use (MMBtu/year)	721	496
Annual energy use (therms/year)	7,207	4,961
Annual energy savings (therms/year)	**-**	**2,246**

The annual energy savings calculated for this measure were 2,246 therms/year. This yields a gas realization rate of 340%.

The broiler manufacturer also estimates electricity savings associated with the upgrade of 4,893 kWh/yr due to reduced electricity use by the broiler. This estimate is based on an online manufacturer's savings estimate tool that allows inputs and takes into account the annual operating hours of the site.

In theory there is additional benefit in the form of reduced ventilation requirements and reduced heat gain but for this retrofit application evaluators believe such associated savings are unlikely. While some of the heat is radiated to other solids, most of the heat is exhausted, air conditioning in the kitchen is indirect, and the ventilation-hood fan speed was not adjusted downward in response to the new broiler's installation.

2.1.7. Data Measurement

Interview, inspect, and perform spot measurements as needed to:

- Verify measure installation
- Collect nameplate data
- Ask if equipment is operating properly
- Verify values of important variables
- Verify broiler is natural gas fired
- Collect operating hours and estimated production quantities

Variable	Deemed	Evaluation Inspection	Reasonable Long Term Range
Annual operating hours	2,496 hrs	7,644 hrs (4,056 off-peak hrs) (3,588 on-peak hrs)	7,644 hrs (4,056 off-peak hrs) (3,588 on-peak hrs)
Broiler efficiency	30%	n/a	n/a
Unloaded gas demand	n/a	67,250	67,250
Loaded gas demand	n/a	61,900	61,900

2.1.8. Site Sampling Strategy

Sampling is not required for this measure.

2.1.9. Uncertainties

Uncertainties arise due to multiple factors:

- The numbers used in this analysis are based on a performance test performed by an outside source rather than actual measurements taken by the evaluators. The results have been tailored to site-reported schedule.
- Actual on-peak and off-peak cooking times vary depending on number of customers eating at the restaurant. These numbers were estimated by the evaluators.
- There is a high degree of uncertainty associated with the electric savings. While the claimed premise is technologically valid, the quantitative estimate in this report relies solely on calculations from an unvetted manufacturer's savings tool.

2.1.10. Non-Energy Impacts

The manufacturer claims the product reduces cleaning time by 25 to 30 minutes per day, which at a fully burdened labor rate of $10 /hour, is worth $1,532 /year. We were unable to verify this information for the facility; however discussions with similar facilities in the New York city area that installed the same measure indicated that the manufacturer claimed cleaning time savings were accurate.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The reasons for deviation are as follows:

- Deemed savings values are determined based on typical broiler operations and efficiencies and are not necessarily specific to the site. Due to this fact, the savings values reported were not representative of what the real impact at this site would be.
- The savings calculations performed in this evaluation used information that was relevant to the actual baseline and proposed broilers and real restaurant operating hours instead of generic measure values.
  - Annual operating hours were 7,644 instead of 2,496.
  - The deemed broiler, existing and proposed, was 40% smaller than the installed units.
  - The deemed broiler, existing and proposed, ran 7 FLH/day compared to the installed 21 FLH per day.

3.2. Deviations from Plan

There were no deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend requiring that the cooking efficiency be listed on product literature or specifications that is submitted with the applications.

3.4. Customer Alert

The store manager was helpful in showing us the installed broiler and discussing its operation.

3.5. Contextual Data

Not applicable for verification sites.

3.6. Evaluation Dates

Assignment date	n/a
Plan approval date	n/a
Site visit date(s)	3/9/10
Draft site report completion date	3/19/10

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

EF7

April 19, 2010

SUMMARY INFORMATION

Project ID	EF7
Program Being Evaluated	Existing Facilities Program
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Hospitality
Customer Business/Product	Restaurant

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Chris Zimbelman
Report Author	Chris Zimbelman

1. PROJECT SUMMARY

This measure involved the replacement of a commercial conveyor style kitchen broiler with a new flexible batch broiler.

1.1. Savings

Meas. ID	Measure Name		Electricity Savings (kWh/yr)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Installation of new batch broiler	Reported	0	66.1	$500
		Evaluated	4,193	187.5	-
		Realization Rate	n/a	284%	-

1.2. Measure Sampling

Measure sampling was not necessary. All the equipment included in the project was evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	Site Evaluation Cost / Incentive
M&V plan	3	$318	
On site M&V	4	$424	
Analysis	6	$636	
Report	4	$424	
Total	17	$1,802	$1,802/$500

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #1: New Flexible Batch Broiler

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

This was the replacement of a conveyor style broiler without burner cycling, with a flexible batch style broiler that contains an enclosed cooking chamber and burner cycling. The deemed savings for this measure were reported by NYSERDA using a pre-determined baseline of a broiler with 15% cooking efficiency and 2,496 annual operating hours.

2.1.2. Evaluation Description of Baseline

The baseline used for this evaluation was the broiler that was installed prior to the flexible batch broiler, which was a Nieco 950 conveyor broiler. During the interview the site contact verified that the prior boiler was still functioning at the time of replacement and that indeed it was a constant-firing model.

2.1.3. Seasonable Variability in Schedule and Production

Broiler operation fluctuates within the operating hours of the restaurant, with peak hours happening during meal times. Restaurant operation is relatively constant throughout the year.

2.1.4. Application Description of As-Built Equipment and Operation

One Duke Flexible Batch Broiler was installed at the restaurant. This broiler utilizes an enclosed cooking chamber to produce product. Rather than running continuously as the conveyor broiler did, this broiler uses thermostatic control to cycle the burner on and off to control to a temperature setpoint, which reduces energy use during non-cooking periods.

2.1.5. Applicant Energy Savings Algorithms

Measure impacts were determined from deemed savings values, meaning the savings were based on a predetermined therm/unit basis rather than actual energy savings for the installed equipment. Savings estimations were based on conveyor boilers with a baseline cooking efficiency of 15% requiring 53 kBtu/hr gas input and a proposed cooking efficiency of 30% along with 2,496 annual operating hours. Total reported savings were 66.1 MMBtu or **661 therms**.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators used information obtained at our site visit, along with published information on the baseline and proposed broilers to calculate the impact of the installation of the new Duke Flexible Batch Broiler.

Energy savings for this measure are directly related to the operational profile of the restaurant. This is due to the fact that a large part of the energy savings is due to the burner cycling instead of running continuously during off-peak times. In order to account for this, evaluators created an hourly weekday and weekend day profile of the restaurant based on information collected during site visits. These profiles accounted for the number of hours per day when the restaurant was closed (broilers off), the number of off-peak cooking hours per day, and the number of on-peak cooking hours per day. The combined weekly profile for this restaurant was as follows:

Table 1: Restaurant Operating Profile

Restaurant Weekly Profile	
Off-peak hours/week	83
On-peak hours/week	47
Closed hours/week	38
Total hours/week	168

Using this profile, along with information obtained from a published Food Service Technology Center study[1] on these batch broilers, evaluators calculated energy use for the baseline and proposed broilers. The report published the energy input rates (Btu/hr) for both the baseline and proposed broilers in “preheat,” “idle,” and “cooking” modes for the same broiler models removed and installed in this project. Evaluators used these values along with the restaurant cooking schedule to calculate annual energy use for both the baseline and proposed cases. We used the “idle” energy rate along with off-peak hours and the “cooking” energy input rate with on-peak hours. A summary of this calculation can be seen below:

Weekly Gas Use (Btu/week) = **off-peak hours** (hours/week) x **broiler idle energy rate** (Btu/hr) + **on-peak hours** (hours/week) x **broiler “cooking” energy input** (Btu/hr)

Table 2 below shows a summary of the calculated energy use for the baseline and installed broilers.

[1] *PGE Foodservice Equipment Workpapers, Gas Equipment, Pilot Measure 3: Flexible Batch Broiler-Gas, Measure Code: F152,* August 2007. This workpaper cites an FSTC study that compared energy use of these exact two broilers. For comparison, the results from that study found 1,438 therms/year in savings using 15-hour days.

Table 2: Energy Use Summary

Energy Use Summary	Conveyor Broiler	Duke Broiler with Catalyst
Gas preheat energy (Btu)	19,600	22,980
Gas idle energy rate (Btu/hr)	89,500	67,250
Gas cooking energy rate (Btu/hr)	99,400	61,900
Weekly energy use (MMBtu/week)	12.12	8.51
Annual energy use (MMBtu/year)	630	443
Annual energy use (therms/year)	6,302	4,427
Annual energy savings (therms/year)	**-**	**1,875**

The annual energy savings calculated for this measure were 1,875 therms/year. This yields a gas realization rate of 284%.

The broiler manufacturer also estimates electricity savings associated with the upgrade of 4,193 kWh/yr due to reduced electricity use by the broiler. This estimate is based on an online manufacturer's savings estimate tool that allows inputs and takes into account the annual operating hours of the site.

In theory there is additional benefit in the form of reduced ventilation requirements and reduced heat gain but for this retrofit application evaluators believe such associated savings are unlikely. While some of the heat is radiated to other solids, most of the heat is exhausted, air conditioning in the kitchen is indirect, and the ventilation-hood fan speed was not adjusted downward in response to the new broiler's installation.

2.1.7. Data Measurement

Interview, inspect, and perform spot measurements as needed to:

- Verify measure installation
- Collect nameplate data
- Ask if equipment is operating properly
- Verify values of important variables
- Verify broiler is natural gas fired
- Collect operating hours and estimated production quantities

Variable	Deemed	Evaluation Inspection	Reasonable Long Term Range
Annual operating hours	2,496 hrs	6,760 hrs (4,316 off-peak hrs) (2,444 on-peak hrs)	6,760 hrs (4,316 off-peak hrs) (2,444 on-peak hrs)
Broiler efficiency	30%	n/a	n/a
Unloaded gas demand	n/a	67,250	67,250
Loaded gas demand	n/a	61,900	61,900

2.1.8. Site Sampling Strategy

Sampling is not required for this measure.

2.1.9. Uncertainties

Uncertainties arise due to multiple factors:

- The numbers used in this analysis are based on a performance test performed by an outside source rather than actual measurements taken by the evaluators. The results have been tailored to site-reported schedule.
- Actual on-peak and off-peak cooking times vary depending on number of customers eating at the restaurant. These numbers were estimated by the evaluators.
- There is a high degree of uncertainty associated with the electric savings. While the claimed premise is technologically valid, the quantitative estimate in this report relies solely on calculations from an unvetted manufacturer's savings tool.

2.1.10. Non-Energy Impacts

The manufacturer claims the product reduces cleaning time by 25 to 30 minutes per day, which at a fully burdened labor rate of $10 /hour is worth $1,532 /year. We asked the site contact whether this benefit was real and he reported that the figures were relatively accurate. He estimated reduced cleaning time to be between 20 and 45 minutes per day.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The reasons for deviation are as follows:

- Deemed savings values are determined based on typical broiler operations and efficiencies and are not necessarily specific to the site. Due to this fact, the savings values reported were not representative of what the real impact at this site would be.
- The savings calculations performed in this evaluation used information that was relevant to the actual baseline and proposed broilers and real restaurant operating hours instead of generic measure values.
    - Annual operating hours were 6,760 instead of 2,496.
    - The deemed broiler, existing and proposed, was 40% smaller than the installed units.
    - The deemed broiler, existing and proposed, ran 7 FLH/day compared to the installed 19 FLH per day.

3.2. Deviations from Plan

There were no deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend requiring that the cooking efficiency be listed on product literature or specifications that are submitted with the applications.

3.4. Customer Alert

The store manager was helpful in showing us the installed broiler and discussing its operation.

3.5. Contextual Data

Not applicable for verification sites.

3.6. Evaluation Dates

Assignment date	n/a
Plan approval date	n/a
Site visit date(s)	3/9/10
Draft site report completion date	3/19/10

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets or model input files

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified

Contract ID	EF8
Site Name	EF8
NYSERDA Program Component	
Site Contact	
Site Address	
Nexant Project Reviewer	Victor Narkaj & Salil Gogte
Nexant Project Inspector	Mark Maloney
Inspection Date and Time	7/16/2008

Measure Description	**Boilers**	
	NYSERDA	**Nexant**
Boiler Manufacturer	Raypak	Raypak
Boiler Model	Hi Delta H9-1532B	Hi Delta H9-1532B
Boiler Input Capacity, kBtu/hr	1,530	1,530
Boiler Quantity	2	2
Boiler Fuel	Natural Gas	Natural Gas
Hot Water End Use	space heating	space heating
Baseline MMBtu Consumption		1,118
Retrofit MMBtu Consumption		980
MMBtu Savings	181	138

Measure Description	**Pipe Insulation**	
	NYSERDA	**Nexant**
Insulation Manufacturer	Knauf	Knauf
Total Insulation Length, Feet	700	700
Insulation Thickness	1.0	1.0
Total footage of piping at 2.5" diameter	N/A	N/A
Total footage of piping at 3" diameter	N/A	N/A
Total footage of piping at 4" diameter	N/A	N/A
Supply Temperature, space heating (ºF)	N/A	N/A
Hours of Operation, space heating	N/A	N/A
MMBtu Savings	483.7	see above

MMbtu Gas Savings	665	138
Gross Realization Rate		21%

Inspection and Review Notes:	1. This project included boiler replacement and pipe insulation at a school affiliated with EF8 2. There were no operational changes in the building between the "pre" and "post" cases. Changes in gas consumption are due only to HDD differences year over year and efficiency improvements offered by the installed measures. 2. The projected boiler gas usage was calculated using a regression formula developed from the "pre gas usage". Post gas usage HDD's were feed in to the regression trend to calculate the projected boiler gas usage. This accounts for any weather differences between the pre and post cases. The savings were calculated by subtracting actual post gas usage (gas bills) from the calculated projected usage. 3. The regression trendline has an acceptable linear correlation with a 95% R^2 value. 4. Calculated boiler savings are 12% which is higher than the 10% level established for validity. 5. Pipe insulation NYSERDA savings are not provided in the buildings portal, nor in project documentation. 6. Nexant pipe insulation savings are based on 3EPlus4 software. Savings are calculated as bare pipe loss minus insulated pipe loss. There was an estimated 700feet of total pipe length (560' at 2.5"diameter, 70' at 3", and 70' at 4").

ERS Review Notes	1. Savings resulted from billing analysis include the boiler and the insulation measures impact 2. The project was inspected in December 2007. The boiler measure was invoiced in December 2007, while the insulation measure was invoiced in October 2007. The baseline gas usage accounts for the winter months until March 2007, while the post-retrofit gas usage accounts for the winter months starting with October 2007. Measure impacts have been evaluated as the HDD normalized difference in gas use between the pre- and post-implementation utility bills.

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	EF9
Site Name	EF9
NYSERDA Program Component	
Nexant Project Reviewer	Salil Gogte
Nexant Project Inspector	Salil Gogte
Inspection Date and Time	5/6/2007

Measure Description	**Steam Trap Maintenance**	
	NYSERDA	**Nexant**
Steam Trap Manufacturer	Barnes & Jones	Barnes & Jones
Steam traps replaced	296	
Steam traps inspected - *random*		50
Boiler Fuel	Natural Gas	Natural Gas
Hot Water End Use		Space heating
Annual heating gas use (baseline) MMBtu- *obtained from billing data*		10,014
DSD reported savings - percentage of baseline energy use	10%	10%
NYSERDA Reported MMBtu Savings	917	
MMbtu Gas Savings	917	1,001
Gross Realization Rate		109%
Inspection and Review Notes:	1. Nexant randomly sampled and inspected approximately 17% of the steam traps rapaired or replaced at EF9. Nexant verified the manufacturer name, type of trap and location and found that all inspected traps were installed as per specification. Nexant was unable to inspect the trap operation because the inspection was completed during the summer cooling period and the heating system was shut down. Facility staff, however, indicated that majority of the new traps were operating satisfactorily and complaints were minor. 2. Nexant conducted a billing regression analysis using HDD as the independent variable to estimate savings, however, the monthly calculated savings do not fall within the 90% or 80% prediction intervals, so regression analysis is not reliable and cannot be used. 3. NYSERDA reported savings are based on DSD values. Estimated savings for steam trap maintenance measures are 10% of the annual baseline energy consumption, as reported in the DSD. Nexant used DSD reported values and adjusted savings for the actual baseline energy consumption calculated from the available billing data. 4. Nexant noted that the Con Edison account number reported in the project documents is for the cooking gas meter. Nexant obtained the correct account number for the boilers from the maintenance personnel.	

ERS Review Notes	- No comments.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES37

4/29/2010

SUMMARY INFORMATION

Project ID	ES37
Program Being Evaluated	NY ENERGY STAR Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	
Customer Business/Product	Multi-family, whole building

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new ENERGY STAR qualified home in Bronx, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	26.0	-
		Evaluated	-	62.1	-
		Realization Rate	-	2.4	-
2	Domestic Hot Water Heating	Reported	-	18.0	-
		Evaluated	-	12.0	-
		Realization Rate	-	0.77	-
3	Appliances	Reported		-	
		Evaluated		0.4	
		Realization Rate		-	
Total		Reported	-	44.0	$1,500
		Evaluated	-	74.55	-
		Realization Rate	-	1.77	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	242%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for 1335 Chisholm Street.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected for the previous two years, through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Annual average gas use	1444
Space Heating	1030
DHW	282.8
Lighting & Appliances (Less DHW)	130.8
Total	1444

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (116 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1465	914	38%
Heating (kWh)	-	-	-
Water Heating (Therms)	390	274	30%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	4,176	4,176	4,176	4,176
Number of windows	19	19	19	19

[2] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Occupants	4	4	4	4
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	4	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	65°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	200 cfm (5 hr/day)	200 cfm (5 hr/day)	210 cfm (24 hr/day)	210 cfm (24 hr/day)[3]
Space Heating Boiler Efficiency	78% AFUE	85% AFUE	86.1% AFUE	86.1% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	80%EF	80%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	39.4	53.5	-	53.5
Above Grade Walls UA (Btuh/F)	195.9	284.0	-	284.0
Windows and Doors (Btuh/F)	184.6	149.2	-	149.2
Basement Walls UA (Btuh/F)	99.2	98.4	-	98.4
Window U-Factor (Btuh/ft2F)	0.4	0.321	-	0.321
Basement Walls	46.6	61.6		61.6
Skylight UFactor (Btuh/ft2F)	3.8	8.3		8.3
Overall UA (Btuh/F)	470.0	556.2	-	556.2
Dishwasher EF	0.46	0.46	-	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	116 Gal/day	-	-	116 Gal/day

[3] Simulation ventilation rate has automatically been set to 133 cfm by the software to meet the requirements of ASHRAE 62.2.

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The homeowner's portion of the site was equipped with two programmable thermostats set to 70°F. Each tenant was supplied with one programmable thermostat. The tenant on the middle floor used a setpoint of 74°F while the top floor tenant used a setpoint of 70F.

However, when simulating comparisons between the as-built home and an EnergyStar reference home, REM/Rate defaults to using programmable thermostats with a 68°F occupied setpoint and a 63°F unoccupied setpoint[4]. These were the setpoints modeled in this evaluation.

Envelope Properties

The width of the exterior wall was visually verified to be greater than 8". A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was too low to provide accurate heat flux readings across the building envelope.

Boiler Efficiency

A spot measurement of the boiler efficiency was not able to be performed due to a lack of access to the flue stack. In addition, the outdoor ambient air temperature was high enough to preclude the need for heating in the home. In lieu of the lack of a spot boiler efficiency measurement the manufacturer rated efficiency, of 86.1% AFUE and effective water heater efficiency of 80%, was entered into REM/Rate for the purpose of the evaluation.

Appliance Gas Use

The site has been credited with a 1% reduction in annual hot water use as a result of installing ENERGY STAR qualified dishwashers and clothes washers. Clothes that are washed with ENERGY STAR washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the ENERGY STAR Clothes Washer and Dishwasher savings calculators[5] and were found to be .4 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

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[4] If there is a programmable thermostat with setback abilities present the setback schedule assumes a 5 degree offset from 11pm to 7am for heating and 9am to 3pm for cooling, as per the RESNET HERS Standards.

[5] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	165.2	103.0	62.1	38%
DHW	40.3	28.3	12.0	30%
Appliances	13.5	13.1	0.4	-
Total	219	144	74.5	34%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 1% reduction in hot water use as a result of the high efficiency dishwasher. This number is estimated based on reliable benchmarks[6], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 495 gallons/yr[7]. This equates to $4 in annual water and sewer charge savings.

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[6] Additional 1% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[7] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 169%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (4,176 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	4,176 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	4/5/2010
Plan approval date	n/a

Site visit date(s)	3/25/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES38

4/28/2010

SUMMARY INFORMATION

Project ID	ES38
Program Being Evaluated	NY ENERGY STAR Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Single Family Home
Customer Business/Product	Single Family Home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new ENERGY STAR qualified home in Bronx, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, ventilation system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	28.0	-
		Evaluated	-	33.9	-
		Realization Rate	-	1.2	-
2	Domestic Hot Water Heating	Reported	-	19.0	-
		Evaluated	-	14.6	-
		Realization Rate	-	0.8	-
3	Appliances	Reported	-	-	
		Evaluated	-	6.9	
		Realization Rate	-	-	
Total		Reported	-	47.0	$2,250
		Evaluated	-	55.3	-
		Realization Rate	-	1.2	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water Measures, and Other Gas Impact Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, ventilation system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an ENERGY STAR qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-Built Equipment and Operation

The building is classified as a multi-family building and has three plus above grade floors, a basement, and is bordered on either side by other homes. The slab floor is specified as being uninsulated while the foundation walls are specified with R-8 insulation. The front and back above-grade-walls are insulated

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an ENERGY STAR reference home (HERS Score of 80).

with R-13 fiber glass material. The ceilings are specified as having R-21 insulation. Windows rated with a U-value of .32 and a SHGC of .41 are used throughout the building.

The home is equipped with a LAARS Endurance combination natural gas boiler/water heater system with a rated efficiency of 86.1% AFUE an effective water heating efficiency of 80%. The home is divided into two thermal zones, one for the first floor apartment and one for the top two floors. Programmable Thermostats in used in each zone meet the heating needs of the homeowner and allow for close control of temperature setpoints. There is no central cooling system in the home as window AC units are installed during the summer months.

An automatically controlled mechanical system delivers 210 CFM of continuous ventilation to the home. All duct work has been sealed and is located within the conditioned space.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a ENERGY STAR reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

Table 1: Annual Gas Use Algorithm Example

DHW MMBTU Calculations:	Theoretical Example Calculation
A. Rated HERS Score	93
B. Base HERS Score	81.3
C. Subtract Base from Rated HERS Score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

Baseline DHW by REGION	DHW (MMbtu/yr)
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LONG ISLAND	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LONG ISLAND	110.2

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the previous two years, through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[3]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Annual average gas use	1105
Space Heating	619
DHW	340.2
Lighting & Appliances (Less DHW)	145.8
Total	1105

It was taken that the home's central heating system was typically only used during the winter months. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (199 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1464	946	35%
Heating (kWh)	95	84	12%
Water Heating (Therms)	670	469	30%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Annual Occupied Hours (hrs/year)	Typical	Typical	Typical	Typical
Floor area (sq.ft.)	4,231	4,231	4,231	4,231
Number of Windows	17	17	17	17
Number of Occupants	12	12	12	12
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year

[4] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Thermostats	2	2	2	2
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	200 cfm (5 hr/day)	200 cfm (5 hr/day)	210 cfm (24 hr/day)	210 cfm (24 hr/day)[5]
Space Heating Boiler Efficiency	78% AFUE	85% AFUE	86.1% AFUE	86.1% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	80%EF	80%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	39.4	53.5	-	53.5
Above Grade Walls UA (Btuh/F)	189.2	275.6	-	275.6
Windows and Doors (Btuh/F)	184.6	149.2	-	149.2
Basement Walls UA (Btuh/F)	99.2	98.4	-	98.4
Window U-Factor (Btuh/ft2F)	0.4	0.321	-	0.321
Basement Walls	46.6	61.6		61.6
Skylight UFactor (Btuh/ft2F)	3.8	8.3		8.3
Overall UA (Btuh/F)	463.6	548.3	-	548.3
Dishwasher EF	0.46	0.46	-	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	199 Gal/day	-	-	199 Gal/day

Thermostat Setpoints

[5] Simulation ventilation rate has automatically been set to 133 cfm by the software to meet the requirements of ASHRAE 62.2.

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 70°F. However, when simulating comparisons between the as-built home and a home built to comply with the New York State Energy Conservation Construction Code (NYSECCC), REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The width of the exterior wall was visually verified to be greater than 8". A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was too low to provide accurate heat flux readings across the building envelope.

Boiler Efficiency

A spot measurement of the boiler efficiency was not able to be performed due to a lack of access to the flue stack. In addition, the outdoor ambient air temperature was high enough to preclude the need for heating in the home. In lieu of the lack of a spot boiler efficiency measurement the manufacturer rated efficiency, of 86.1% AFUE and effective water heater efficiency of 80%, was entered into REM/Rate for the purpose of the evaluation.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing ENERGY STAR qualified dishwashers and clothes washers. Clothes that are washed with ENERGY STAR washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the ENERGY STAR Clothes Washer and Dishwasher savings calculators[6] and were found to be 6.9 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

[6] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	96	62	33.9	35%
DHW	49	34	14.6	30%
Appliances	21	15	6.9	-
Total	166	110	55.3	33%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- Performed spot measurements of space heating boiler efficiency and space temperature
- Window make and model number was verified to be double paned windows
- Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot
Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[7], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 33,180 gallons/yr[8]. This equates to $288 in annual water and sewer charge savings.

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[7] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[8] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 118%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (4,231 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	4,231 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	4/5/2010
Draft site report completion date	4/23/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES39

4/29/2010

SUMMARY INFORMATION

Project ID	ES39		
Program Being Evaluated	NY ENERGY STAR Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Single Family Home		
Customer Business/Product	Single Family Home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new ENERGY STAR qualified home in Scarsdale, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, ventilation system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	31	-
		Evaluated	-	104.9	-
		Realization Rate	-	3.38	-
2	Domestic Hot Water Heating	Reported	-	21	-
		Evaluated	-	1.6	-
		Realization Rate	-	0.08	-
3	Appliances	Reported			
		Evaluated		1.8	
		Realization Rate			
Total		Reported	-	52.0	$1,750
		Evaluated	-	108.2	-
		Realization Rate	-	2.08	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water Measures, and Other Gas Impact Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, ventilation system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an ENERGY STAR qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-Built Equipment and Operation

The building is classified as a single family unit and has two above grade floors and a basement. The slab floor is specified with R-10 insulation. The above-grade-walls are insulated with R-21 insulation. The

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an ENERGY STAR reference home (HERS Score of 80).

ceiling R-value varies depending on the stud thickness with insulation values between R-23 and R-41. Pella double paned windows with a U-value of 0.32 and a SHGC of 0.30 are used throughout the home.

The heating system consists of two natural gas furnaces with a manufacturer specified AFUE of 94.1. The building is also furnished with two split system A/C units ranging in size from 2-3 tons with a seasonal energy efficiency rating (SEERs) of 15. The home is divided into two thermal zones with forced-air space conditioning. Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the homeowner. Both thermostats are equipment with temperature setback.

One exhaust fan moves 100 cfm of fresh air for 2.5 hrs per day.

Domestic hot water is supplied via a 75 gallon gas-fired water heater with a rated energy factor of 60%. The home's dryer, range, and stove are all electric.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a ENERGY STAR reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

Table 1: Annual Gas Use Algorithm Example

DHW MMBTU Calculations:	Theoretical Example Calculation
A. Rated HERS Score	93
B. Base HERS Score	81.3
C. Subtract Base from Rated HERS Score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

Baseline DHW by REGION	DHW (MMbtu/yr)
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LONG ISLAND	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LONG ISLAND	110.2

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[3]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

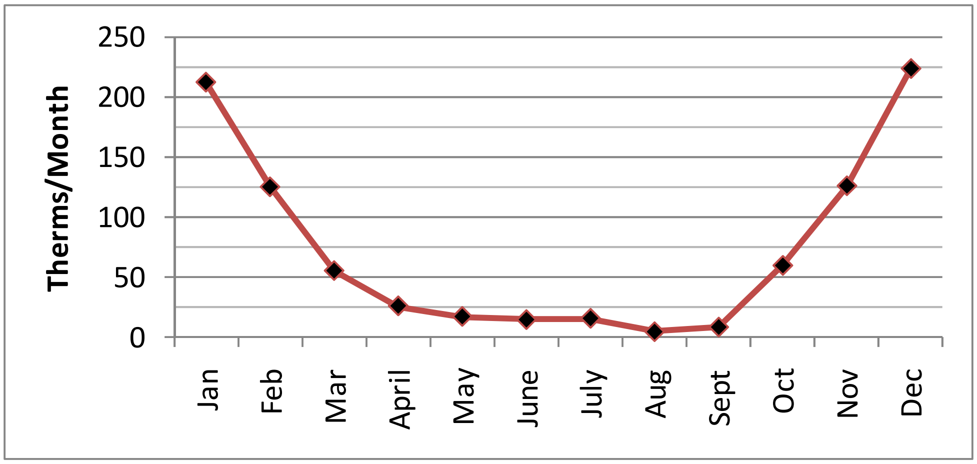
[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	756
DHW	94
Lighting & Appliances (Less DHW)	40
Total	890

Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in October. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

Figure 1: Average Monthly Gas Use



Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	2113	970	54%
Heating (kWh)	-	-	-
Water Heating (Therms)	184	157	15%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Annual Occupied Hours (hrs/year)	Typical	Typical	Typical	Typical
Floor area (sq.ft.)	5,602	5,602	5,602	5,602
Number of Occupants	4	4	4[5]	4
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	2	2	2	2
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	unknown	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	100 cfm (2.5 hr/day)	100 cfm (2.5 hr/day)	100 cfm (2.5 hr/day)	100 cfm (2.5 hr/day)
Space Heating Furnace Efficiency	78% AFUE	94.1% AFUE	94.1% AFUE	94.1% AFUE
Domestic Hot Water Heater Energy Factor	58% EF	60% EF	60%EF	60%EF
Exterior wall thickness	n/a	n/a	5 ½”	5 ½”
Exterior Roof Insulation Thickness	n/a	n/a	10-12”	10-12”
Ceiling UA (Btuh/F)	83.5	63.2	-	63.2
Above Grade Walls UA (Btuh/F)	295.8	200.8	-	200.8
Windows and Doors (Btuh/F)	290.8	234.1	-	234.1
Floors Over Garage (Btuh/F)	24.3	17.1	-	17.1
Basement Walls UA (Btuh/F)	85	100.8	-	100.8

[4] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

[5] The home is occupied by 2 adults and 2 small children (under 5 years old)

Window U-Factor (Btuh/ft2F)	0.4	0.32	-	0.32
Overall UA (Btuh/F)	779.4	616.1	-	616.1
Clothes Dryer	Electric	Electric	Electric	Electric
Oven/Range	Electric	Electric	Electric	Electric
Hot Water Use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. On average, when the home was occupied, the heating setpoint was equal to 70°F. The setback temperature was not known. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The width of the wall insulation was verified to be 5 ½”. The roof insulation was not accessible and its installation was therefore not verified.

A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was ~5°F, which is too low to provide accurate heat flux readings across the building envelope.

Furnace Efficiency

The furnace was not running at the time of the evaluator’s site visit. Therefore, spot readings of combustion efficiency were not taken. The manufacturer’s efficiency was verified to be 94.1 AFUE with direct vent upflow like that observed on-site. The simulated furnace efficiency was therefore set to 94.1 AFUE.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	193.9	89.0	104.9	54%
DHW	11.0	9.4	1.6	15%
Appliances	5.8	4.0	1.8	30%
Total	211	102	108.2	51%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- Performed spot measurements of space heating boiler efficiency and space temperature
- Window make and model number was verified to be double paned windows
- Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot
Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

A copy of the site visit survey template is attached as Appendix A.

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 10% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[6], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 8,021 gallons/yr[7]. This equates to $70 in annual water and sewer charge savings.

[6] Additional 10% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[7] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was208%. The space heating measure realization rate was 338%, while the domestic hot water realization rate was 8%.

Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (5,602 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for space heating gas use impacts in *ex post* calculations.

The *ex post* domestic hot water impacts are calculated from the REMRate simulated % reduction in domestic hot water heating with the installed system. The % reduction (23%) applied in evaluation calculations was much lower than that applied in claimed savings calculations (58%), leading to much lower *ex post* measure impacts. Further, the domestic hot water gas use from utility bills was only 94 therms/year (9.4 MMbtu/year), which is significantly lower than the as-built gas use predicted in claimed savings calculations, and contributes to the much lower *ex post* measure impact.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—

Total building floor area affected by retrofit	5,602 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	4/6/2010
Draft site report completion date	4/29/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES40

5/11/2010

SUMMARY INFORMATION

Project ID	ES40
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Single Family Home
Customer Business/Product	Single Family Home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager	n/a		
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Betsy Ricker
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, ventilation system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

1.1. Savings

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space heating	Reported	-	32	-
		Evaluated	-	161.5	-
		Realization Rate	-	5.05	-
2	Domestic hot water heating	Reported	-	22	-
		Evaluated	-	11.7	-
		Realization Rate	-	0.53	-
3	Appliances	Reported	-		
		Evaluated	-	3.3	
		Realization Rate	-	-	
Total		Reported	-	54	$1,750
		Evaluated	-	176.6	-
		Realization Rate	-	3.27	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	**Hours**	**Cost Including Expenses**	
M&V plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water Measures, and Other Gas Impact Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, ventilation system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an Energy Star qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-built Equipment and Operation

The building is classified as a single family unit and has three above-grade floors and a basement. The slab floor is specified with R-10 insulation. The above-grade walls are insulated with R-26 spray foam material. The ceiling R-value varies depending on the stud thickness with insulation values between R-39

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an Energy Star reference home (HERS Score of 80).

and R-54. Marvin double-paned windows with a U-value of .31 and a SHGC of .30 are used throughout the building.

The heating system consists of a natural gas boiler with a measured efficiency of 83%. The building is also furnished with five split-system A/C units ranging in size from 2-3 tons and seasonal energy efficiency ratings (SEERs) from 14 to 19. The home is divided into seven thermal zones: five with forced-air space conditioning zones and two with radiant heat zones. Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the homeowner. Heating and cooling are both controlled by multiple thermostats, one for each of the forced air and radiant heat zones, allowing close control of temperature setpoints.

Two automatically controlled ventilation systems, each equipped with a cross-flow heat recovery system, delivers up to 500 cfm of ventilation to the home for 4 hours per day. During site visits, it was observed that the ventilation rate was set at 10% of the maximum, or 50 cfm. All ductwork has been sealed and is located within the conditioned space.

Domestic hot water is supplied via a 36 gallon indirect-fired water heater with a rated energy factor of 81%.

2.1.5. Measure Life

A study of measure life is not included in this evaluation.

2.1.6. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a Energy Star reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot-water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

Table 1: Annual Gas Use Algorithm Example

DHW MMBTU Calculations:	Theoretical Example Calculation
A. Rated HERS score	93
B. Base HERS score	81.3
C. Subtract base from rated HERS score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for region (e.g., NYC)	76.2
F. DHW Mmbtu savings (D*E)	44.577
Baseline DHW by Region	**DHW (MMbtu/yr)**
West Southern Tier	82.5
NYC	76.2
Rochester	82.2
Buffalo	82.5
Syracuse	83.3
Albany	83.3
Binghamton	85.5
St. Lawrence/Adirondacks	88.1
Long Island	76.2
Baseline Space Heating by Region	**Heating (MMBtu/yr)**
West Southern Tier	130.4
NYC	110.2
Rochester	123.6
Buffalo	130.4
Syracuse	120.1
Albany	118.8
Binghamton	130.9
St. Lawrence/Adirondacks	137.8
Long Island	110.2

2.1.7. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (total annual therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (therms) = Average Summer Therms x 12 x 70%[3]

Annual Non-DHW Appliance Gas Use (therms) = Average Summer Therms x 12 x 30%

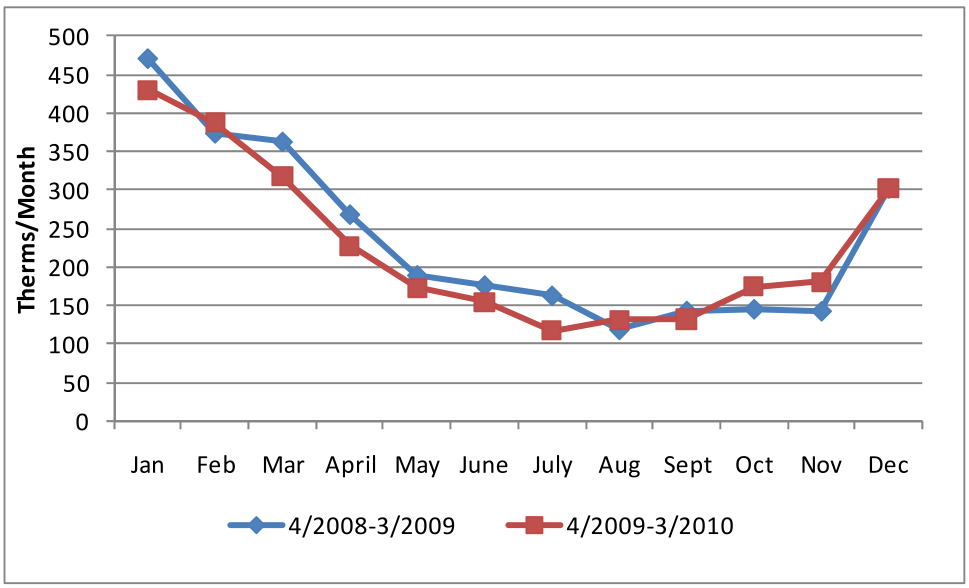
Table 2 shows the average annual space heating, domestic hot water (DHW), and appliance used in the home from April 2008 through March 2010.

Table 2: Annual Gas Use Breakdown

End-Use	Gas (Therms)
Space heating	1242
Domestic hot water	194
Lighting & appliances (less DHW)	83
Total	1519

Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances. Figure 1 shows the therms/month used in the home from April 2008 through March 2010.

Figure 1: Average Monthly Gas Use



However, review of the utility bills for the home indicated that the summer usage was far too high to be attributable to just domestic hot water and gas appliances under typical operating conditions. During the evaluation site visit underfloor hydronic heating was observed in several bathrooms, and it is likely that

[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

much of the extraneous summer usage is due to these systems running throughout the summer for comfort reasons, resulting in gas use by the boilers during these months. This gas use is largely independent of the R-value of home's envelope, and given the relatively low efficiency of the boilers, is not included in the gas impact calculations for this project. The DHW and appliance gas use has therefore been calculated based on the values output by REM/Rate. The space heating energy does not include the estimated usage of the underfloor hydronic heating system.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (83 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis. Table 3 presents the REM/Rate simulation outputs.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYSECCC Baseline	As-built	% Savings
Heating (therms)	3780	1643	57%
Heating (kWh)	188	113	40%
Water heating (therms)	312	194	38%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Annual occupied hours (hrs/year)	Typical	Typical	Typical	Typical
Floor area (sq.ft.)	8,069	8,069	8,069	8,069
Number of occupants	5	5	5	5
Occupancy schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of thermostats	6	6	7	6
Occupied heating temperature setpoint (°F)	68°F	68°F	70°F	68°F

[4] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Unoccupied heating temperature setpoint (°F)	68°F	68°F	70°F	68°F
Occupied cooling temperature setpoint (°F)	78.5°F	78°F	78°F	78.5°F
Unoccupied cooling temperature setpoint (°F)	78.5°F	78°F	78°F	78.5°F
Ventilation rate (exhaust only, cfm)	200 cfm (5 hr/day)	200 cfm (5 hr/day)	20 cfm (24 hr/day)	133 cfm (24 hr/day)[5]
Energy recovery ventilator effectiveness	0%	0%	59%	59%
Space heating boiler efficiency	78% AFUE	85% AFUE	84.1% AFUE	84.1% AFUE
Domestic hot water heater efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½″	5 ½″
Exterior roof insulation thickness	n/a	n/a	10-12″	10-12″
Ceiling UA (Btuh/°F)	176.7	96.4	-	96.4
Above grade walls UA (Btuh/°F)	727.6	345.3	-	345.3
Windows and doors (Btuh/°F)	618.8	493.4	-	493.4
Floors over garage (Btuh/°F)	33.6	2.0	-	2.0
Basement walls UA (Btuh/°F)	99.2	98.4	-	98.4
Window U-Factor (Btuh/ft_2°F)	0.4	0.321	-	0.321
Overall UA (Btuh/°F)	1660.6	1054.4	-	1054.4
Dishwasher EF	0.46	0.46	-	0.46
Clothes dryer	Natural gas	Natural gas	Natural gas	Natural gas
Oven/range	Natural gas	Natural gas	Natural gas	Natural gas
Hot water use	83 Gal/day	-	-	83 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 70°F. However, when simulating comparisons

[5] Simulation ventilation rate has automatically been set to 133 cfm by the software to meet the requirements of ASHRAE 62.2.

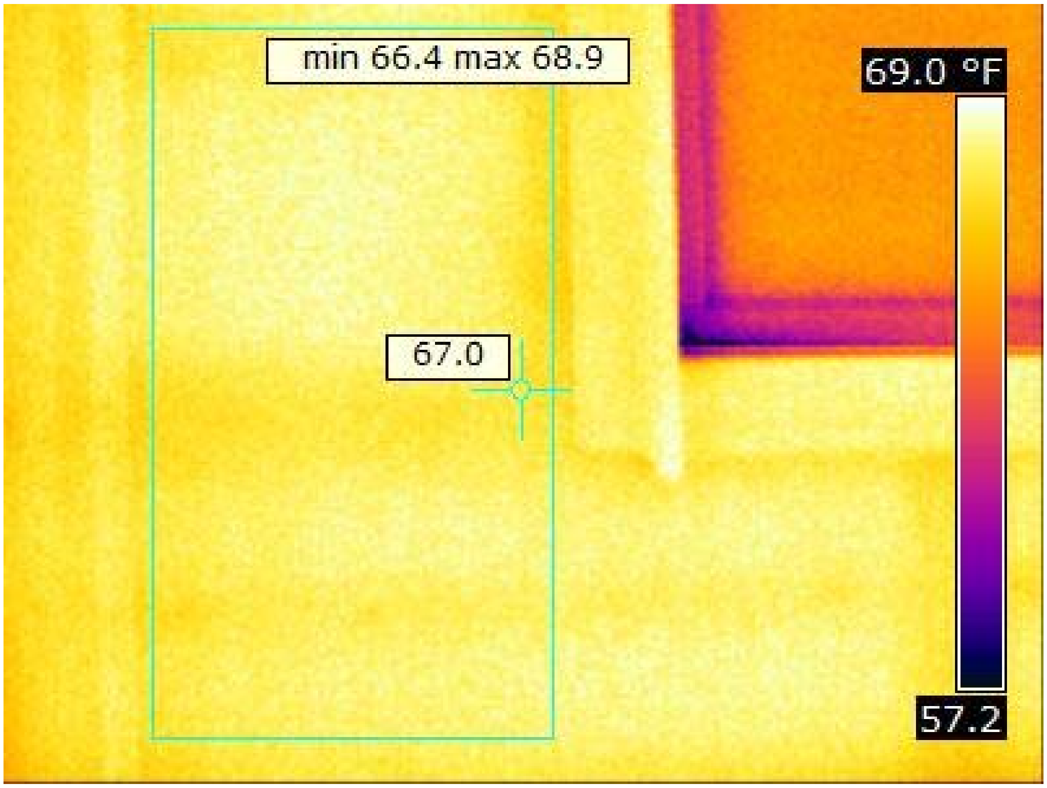
between the as-built home and a home built to comply with the New York State Energy Conservation Construction Code (NYSECCC), REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The width of the wall insulation was verified to be 5 ½″ and the width of the roof insulation was verified to be 10″-12″ in pictures that were taken during the home's construction

Infrared pictures taken on-site verified that the roof insulation was installed as specified in the program application. Pictures taken with an infrared camera indicated interior wall temperatures that were very close to the interior space temperature, indicating a high R-value wall consistent with construction specifications. The relatively uniform temperatures across the wall surface indicate well-installed, continuous insulation consistent with construction documents.

Figure 2: Interior Wall Surface Temperature



Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion. For gas-fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f$$

Where L_f is calculated according AHRI Standard BTS-2000 [6] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet temperature	80°F
Exhaust temperature	260°F
% O_2	10.1%
% CO_2	6.2%
Ratio CO/CO_2	-
Efficiency	84.1%

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 84.1%. Because this boiler did not appear to be modulating and was not a condensing unit, the measured efficiency of 84.1% (which is just under 1% less than the manufacturer's specified boiler efficiency of 85%) is expected to be representative of the annual performance of the boiler.

Appliance Gas Use

The site has been credited with a 12% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[7] and were found to be 3.5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

[6] Based on AHRI Standard BTS-2000 "Method to Determine Efficiency of Commercial Space Heating Boilers"

[7] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (Mmbtu)	% Savings
Heating	286	124	162	57%
DHW	31	19	12	38%
Appliances	8.6	5.1	3.5	41%
Total	326	149	177	54%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.8. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- ❑ Verified the installation of the space heating boiler; ventilators; domestic hot water heaters; wall, roof, and floor insulation; and windows.
- ❑ Performed spot measurements of space heating boiler efficiency and space temperature
- ❑ Window make and model number was verified to be double-paned windows
- ❑ Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- ❑ Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	Combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot
Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

2.1.9. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.10. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with an 12% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[8] but is not site-specific and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 20%

2.1.10. Non-Energy Impacts

High efficiency clothes washers and dishwashers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 16,569 gallons/yr[9]. This equates to $144 in annual water and sewer charge savings.

[8] Additional 11% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[9] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 328%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (>8,000 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

The *ex post* impact algorithm used end-use specific percent savings values outputs from REM/Rate to calculate the space heating and domestic hot water impacts. The *ex ante* savings algorithm used the stated HERS score for the home to calculate an overall percent savings that accounted for both electric and gas impacts in the home. Table 7 summarizes the gas and electric $/year savings from the *ex ante* REM/Rate file as compared to a HERS reference home (reference HERS score = 80). Although this isn't the same baseline used in *ex ante* calculations, this data is easily output by REM/Rate and illustrates the pitfalls of using the total percent savings for the home to estimate the gas impacts for the project.

Table 7: REM/Rate Outputs: HERS Reference Home vs. As-built Home

Annual End Use Consumption	HERS Reference Home	As-built Home	% Savings
Natural gas ($/yr)	5042	2198	56%
Electric ($/yr)	5646	4954	12%
Total ($/yr)	10688	7152	33%

The relatively low electric percent savings neutralize the high gas impacts when calculating the total percent savings for this project. This drives the *ex ante* percent savings value down, resulting in an underestimate of the gas impacts for the project.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	8,069 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/26/2010
Draft site report completion date	4/23/2010

3.7. Checklist

Report submission package includes:
- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES41

4/23/2010

SUMMARY INFORMATION

Project ID	ES41		
Program Being Evaluated	NY ENERGY STAR Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Single Family Home		
Customer Business/Product	Single Family Home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new ENERGY STAR qualified home in Rye, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, ventilation system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure level and represent the anticipated savings over a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	34	-
		Evaluated	-	76.1	-
		Realization Rate	-	2.2	-
2	Domestic Hot Water Heating	Reported	-	23	-
		Evaluated	-	7.2	-
		Realization Rate	-	.3	-
3	Appliances	Reported	-	-	-
		Evaluated	-	4.2	-
		Realization Rate	-	-	-
Total		Reported	-	57	$1,750
		Evaluated	-	87.5	-
		Realization Rate	-	1.5	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water Measures, and Other Gas Impact Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, ventilation system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an ENERGY STAR qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-Built Equipment and Operation

The building is classified as a single family unit and has three above grade floors and a basement. The slab floor is specified with R-5 insulation. The above-grade-walls are insulated with R-20 insulating

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an ENERGY STAR reference home (HERS Score of 80).

material. The roof R-value is R-32. Marvin double paned windows with a U-value of .31 and a SHGC of .30 are used throughout the home.

The heating system consists of a condensing natural gas boiler with a rated AFUE of 95% and a measured efficiency of 87%. The hot water supply temperature is constantly set to 180°F. No supply temperature reset based on outdoor air is employed. The building is furnished with a 4 split system A/C units ranging in size from 2-3 tons with a seasonal energy efficiency rating (SEERs) of 15. The home is divided into five thermal zones, each with their own thermostat. Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the homeowner.

Two automatically controlled ventilation systems, each equipped with a cross flow heat recovery system, delivers up to 440 CFM of ventilation to the home for 4 hours per day. All duct work has been sealed and is located within the conditioned space.

Domestic hot water is supplied via a 80 gallon indirect fired water heater with a rated energy factor of 86%.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a ENERGY STAR reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

Table 1: Annual Gas Use Algorithm Example

DHW MMBTU Calculations:	Example Site
A. Rated HERS Score	93
B. Base HERS Score	81.3

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

C. Subtract Base from Rated HERS Score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577
Baseline DHW by REGION	**DHW (MMbtu/yr)**
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LI	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LI	110.2

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[3]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	1171
DHW	156
Lighting & Appliances (Less DHW)	67
Total	1394

Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were expected to be DHW and appliances. However, review of the utility bills for the home indicated that the summer usage was far too high to be attributable to just domestic hot water and gas appliances under typical operating conditions. During the evaluation site visit underfloor hydronic heating was observed in several bathrooms, and it is likely that much of the extraneous summer usage is due to these systems running throughout the summer for comfort reasons, resulting in gas use by the boilers during these months. This gas use is largely independent of the R-value of home's envelope, and given the relatively low efficiency of the boilers, is not included in the gas impact calculations for this project. The DHW and appliance gas use has therefore been calculated based on the values output by REM/Rate. The space heating energy does not include the estimated usage of the underfloor hydronic heating system.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (66 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	2854	1730	39%
Heating (kWh)	1160	1115	4%
Water Heating (Therms)	228	156	32%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	EnergyStar Reference Home	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Floor area (sq.ft.)	6,549	6,549	6,549	6,549
Number of Occupants	5	5	5	5
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	5	5	5	5
Occupied Heating Temperature Setpoint (F)	68°F	68°F	62-65°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	62-65°F	68°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	150 cfm (18 hr/day)	150 cfm (18 hr/day)	150 cfm (18 hr/day)	150 cfm (18 hr/day)
Energy Recovery Ventilator Effectiveness	0%	80%	80%	80%
Space Heating Boiler Efficiency	78% AFUE	92.1% AFUE	87% AFUE	87% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	149.3	140.8	-	140.8
Above Grade Walls UA (Btuh/F)	468.6	353.7	-	353.7
Windows and Doors (Btuh/F)	347	282.3	-	282.3
Slab Floor (Btuh/F)	5.6	9.2	-	9.2
Floors Over Unconditioned Spaces (Btuh/F)	146.5	113.2	-	113.2

[4] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Window U-Factor (Btuh/ft2F)	0.40	0.324	-	0.324
Overall UA (Btuh/F)	1144.2	918.7	-	918.7
Dishwasher EF	0.46	0.46	-	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	66 Gal/Day	-	-	66 Gal/Day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint varied from room to room and was between 62°F and 65°F. However, when simulating comparisons between the as-built home and an EnergyStar reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

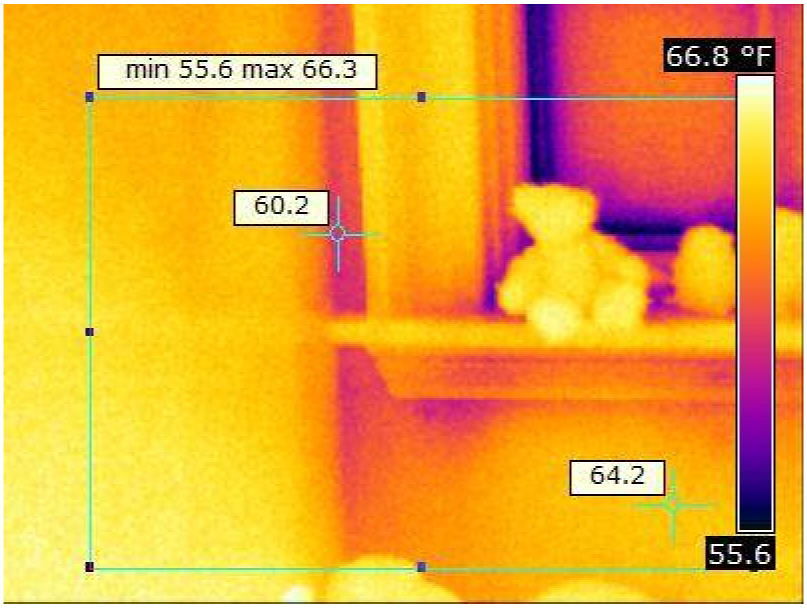
Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Infrared pictures taken on-site verified that the roof insulation was installed as specified in the program application. The outdoor temperature at the time pictures were taken was 42°F. The interior space temperature was spot measured to be 68°F. Pictures taken with an infrared camera indicated interior wall temperatures that were very close to the interior space temperature, indicating a high R-value wall, consistent with construction specifications. The non-uniformity in the temperatures across the wall surface indicates some thermal bridging around the window frame, but overall the insulation appeared to be well installed, and showed high thermal resistance, consistent with construction documents.

Photo 1: Interior Wall Surface Temperature



Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [5] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimatedd using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	42°F
Exhaust Temperature	157°F
% O_2	6.6%

[5] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

% CO_2	8.1%
Ratio CO/CO_2	0.0001
Return Temperature (°F)	unknown
Supply Temperature	189°F (Setpoint = 180°F)

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 87%. Estimating a 20°F temperature drop across the building heating loop, the return temperature was estimated to be 169°F. Given this estimated return temperature and the spot measured flue temperature, no additional improvement in the boiler efficiency was achieved via water condensing out of the exhaust of the boiler. The overall spot measured boiler efficiency was therefore equal to 87%. Since the boilers do not appear to utilize outdoor air reset to lower the supply temperature, this efficiency is expected to representative of the boiler's annual operating efficiency, and was used in place of the manufacturer's specified AFUE when performing evaluation calculations.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing ENERGY STAR qualified dishwashers and clothes washers. Clothes that are washed with ENERGY STAR washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the ENERGY STAR Clothes Washer and Dishwasher savings calculators[6] and were found to be 4.2 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	193.1	117.1	76.1	39%
DHW	22.8	15.6	7.2	32%
Appliances	10.9	6.7	4.2	-
Total	226.8	139.4	87.5	39%

[6] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- Performed spot measurements of space heating boiler efficiency and space temperature
- Window make and model number was verified to be double paned Marvin windows
- Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot
Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

A copy of the site visit survey template is attached as Appendix A.

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and an EnergyStar reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home. Additionally, the program uses defaults to define the domestic hot water and appliance loads, not the true as-built loads, which leads to uncertainty in the calculated appliance energies.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[7], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _30_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 10,939 gallons/yr[8]. This equates to $95 in annual water and sewer charge savings.

[7] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[8] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 153%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (>6,549 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	6,549 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010

Plan approval date	n/a
Site visit date(s)	3/30/2010
Draft site report completion date	4/23/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES42

5/11/2010

SUMMARY INFORMATION

Project ID	ES42
Program Being Evaluated	NY ENERGY STAR Homes
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Townhouse, End Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new ENERGY STAR qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Space heating	Reported	-	36	-
		Evaluated	-	43.7	-
		Realization Rate	-	1.22	
2	Domestic hot water heating	Reported	-	25	
		Evaluated	-	7.5	-
		Realization Rate	-	0.30	
3	Appliances	Reported	-	-	
		Evaluated	-	1.02	
		Realization Rate	-	-	
Total		Reported	-	61.0	$1,750
		Evaluated	-	52.3	-
		Realization Rate	-	0.86	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses
M&V plan	4	$392

On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. Measures Included In The Evaluation

2.1. Space Heating, Domestic Hot Water Heater, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, space temperature controls, and the installation of ENERGY STAR qualified gas appliances. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an ENERGY STAR qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

[1] Note: Equivalent to a maximum HERS "Index" of 80. New York will continue using a HERS "Score" rather than a HERS "Index" as the determination of Program compliance. The Score is calculated as: HERS Score = 80 + (100 - HERS Index)/5.

2.1.4. Application Description of As-Built Equipment and Operation

The building is classified as a townhouse end unit and has two above grade floors. The slab floor is specified with R-10 insulation. The above-grade-walls are insulated with R-20 open cell low density spray foam material. The ceiling has rated insulation value of R-38, while the exposed floor above the garage is rated at R-30. Andersen 200 series windows with a U-value of .330 and a SHGC of .350 are used throughout the building.

The heating system consists of a natural gas boiler with a spot measured efficiency of 86.9% and a rated AFUE of 92%. The building is also furnished with a 3-ton central A/C system with a seasonal energy efficiency rating (SEER) of 14. The home is divided into six thermal zones, two with forced-air space conditioning zones and 4 radiant heat zones. Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the homeowner. Heating and cooling are both controlled by multiple thermostats one for each of the forced air and radiant heat zones, allowing close control of temperature setpoints.

An automatically controlled ventilation system, for the restrooms, equipped with an automatic timer delivers 203 CFM of ventilation to the home for 8 hours per day. All duct work has been sealed with UL-181 compliant sealant and is located within the conditioned space.

Domestic hot water is supplied via a 36 gallon indirect fired water heater with a rated effectiveness of 85%.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a ENERGY STAR reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

Table 1: Annual Gas Use Algorithm Example

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

DHW MMBTU Calculations:	Example Site
A. Rated HERS Score	93
B. Base HERS Score	81.3
C. Subtract Base from Rated HERS Score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577
Baseline DHW by REGION	**DHW (MMbtu/yr)**
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LI	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LI	110.2

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy (3/2008) through March 2010. The annual average gas consumption (total annual therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (therms) = Total annual therms – Average summer therms x 12

Annual DHW gas use (therms) = Average summer therms x 12 x 70%[3]

Annual non-DHW appliance gas use (therms) = Average summer therms x 12 x 30%

Table 2 shows the average annual space heating, domestic hot water (DHW), and appliance used in the home.

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space heating	392.5
Domestic hot water	137.2
Lighting & appliances (less DHW)	58.8
Total	588.5

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Through conversations with the homeowner it was determined that the only gas users in the home during the summer months were the DHW and appliances.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (therms)	831	393	53%
Heating (kWh)	369	45	88%
Water heating (therms)	119	77	35%

Table 4 outlines the variables that were verified during site visits:

[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 4: REM/Rate Simulation Inputs

Variable	EnergyStar Reference Home	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Annual occupied hours (hrs/year)	Typical	Typical	Typical	Typical
Floor area (sq.ft.)	1826	1826	1826	1826
Number of occupants	2	2	2	2
Occupancy schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of thermostats	6	6	6	6
Occupied heating temperature setpoint (F)	68°F	68°F	71°F	68°F
Unoccupied heating temperature setpoint (F)	68°F	68°F	71°F	68°F
Occupied cooling temperature setpoint (F)	78°F	78°F	78°F	78°F
Unoccupied cooling temperature setpoint (F)	78°F	78°F	78°F	78°F
Ventilation rate (exhaust only, cfm)	203 cfm (8 hr/day)	203 cfm (8 hr/day)	203 cfm (8 hr/day)	203 cfm (8 hr/day)
Space heating boiler efficiency	82% AFUE	92% AFUE	86.9% Spot Measured	92% AFUE Average Yearly Eff.
Domestic hot water heater efficiency	60% EF	85% EF	85% EF	85% EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	38.8	26.2		26.2
Above grade walls UA (Btuh/F)	180.6	144.8		144.8
Windows and doors (Btuh/F)	87.5	67.5		67.5
Slab floor (Btuh/F)	8.3	4.7		4.7
Window U-factor (Btuh/F)	.4	.33		.33
Overall UA (Btuh/F)	327	252.3		252.3
Dishwasher EF				
Clothes dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas

[4] The use of defaults to run the EnergyStar comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Hot water use	33 Gal/day	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 71°F. However, when simulating comparisons between the as-built home and a home built to comply with the New York State Energy Conservation Construction Code (NYSECCC), REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 5 ½". Review of the wall insulation with an infrared camera did not indicate any holes or missing insulation. Pictures taken on-site verified that the roof insulation was installed as specified in the program application.

Figure 1: Roof Insulation

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [5] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in table 5.

Table 5: Flue Gas Analysis

Variable	Value
Inlet temperature	36°F
Exhaust temperature	165°F
% O_2	4.9%
% CO_2	9.1%
Ratio CO/CO_2	0.0005

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 86.9%. Although it was not possible to measure on-site, an additional improvement in the boiler efficiency is expected due to water condensing out of the exhaust of the boiler. Conversations with the builder indicated that the installed unit implemented supply water temperature reset based on outdoor air temperature. This typically results in a greater length of time during which the boiler is likely to be condensing, making reasonable to expect that, on average, the boiler is operating at the 92% AFUE specified in manufacturer's documents. This was the AFUE applied in REM/Rate models.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing ENERGY STAR qualified dishwashers and clothes washers. Clothes that are washed with ENERGY STAR washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the ENERGY STAR Clothes Washer and Dishwasher savings calculators[6] and were found to be 1.02 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

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[5] Based on AHRI Standard BTS-2000 "Method to Determine Efficiency of Commercial Space Heating Boilers"

[6] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Baseline Energy (therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	83.0	39.3	43.7	53%
DHW	21.2	13.7	7.5	35%
Appliances	6.9	5.9	1.0	15%
Total	111.1	58.9	52.3	47%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- ❑ Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- ❑ Performed spot measurements of space heating boiler efficiency and space temperature
- ❑ Window make and model number was verified to be Anderson 200
- ❑ Visually inspected the continuity of insulation
- ❑ Requested utility bill data

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot

Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[7], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[8]. This equates to $26 in annual water savings.

[7] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[8] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 86%. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area or the number of occupants in the home into account. Therefore, in a home with a small floor area and only a few occupants, like the one evaluated here (1,826 sq.ft. and three occupants), both the baseline and as-built space heating energy are likely to be lower than specified in *ex ante* calculations, resulting in lower impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	1826
Building predominant year of construction	2009

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/13/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES43

5/11/2010

SUMMARY INFORMATION

Project ID	ES43		
Program Being Evaluated	NY ENERGY STAR Homes		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Single Family Home		
Customer Business/Product	Single Family Home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of adding a new ENERGY STAR qualified addition to an existing home in the Bronx, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, ventilation system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space heating	Reported	-	36	-
		Evaluated	-	67.5	-
		Realization Rate	-	1.87	-
2	Domestic hot water heating	Reported	-	25	-
		Evaluated	-	9.8	-
		Realization Rate	-	0.39	-
3	Appliances	Reported	-	-	
		Evaluated	-	1.6	
		Realization Rate	-	-	
Total		Reported	-	61	$1,750
		Evaluated	-	79.0	-
		Realization Rate	-	1.29	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses
M&V Plan	4	$392

On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water Measures, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, space temperature controls, and the installation of ENERGY STAR qualified gas appliances. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an ENERGY STAR qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-built Equipment and Operation

The building is classified as a single family unit and has three plus above grade floors and a basement. The slab floor is specified as being uninsulated while the foundation walls are specified with R-10 and R-7 insulation for the existing and new portions respectively. The above-grade-walls are insulated with R-14

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an ENERGY STAR reference home (HERS Score of 80).

blown fiberglass. The existing walls of the site were constructed with 4" studs while the new walls use 6" studs. The ceilings are specified as R-38. Bonneville double paned windows with a U-value of .33 and a SHGC of .40 are used throughout the building.

The heating system consists of a Dunkirk Quantum natural gas condensing boiler with a rated efficiency of 95% AFUE. The building is also furnished with 2 split system A/C units ranging in size from 3-3.5 tons and seasonal energy efficiency ratings (SEERs) of 16. The home is divided into two forced-air space conditioning zones. Programmable Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the homeowner and allow for close control of temperature setpoints.

An automatically controlled ventilation system, delivers up to 198 CFM of ventilation to the home for 14 hours per day. All duct work has been sealed and is located within the conditioned space.

Domestic hot water is supplied via a 39 gallon indirect fired water heater with a rated energy factor of 77%.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a ENERGY STAR reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.

Table 1: Applicant Gas Use Algorithm Example

DHW MMBTU Calculations:	Theoretical Example Calculation
A. Rated HERS Score	93
B. Base HERS Score	81.3
C. Subtract Base from Rated HERS Score (A-B)	11.7

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577
Baseline DHW by REGION	**DHW (MMbtu/yr)**
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LONG ISLAND	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LONG ISLAND	110.2

2.1.6. Evaluation Energy Savings Algorithms

The home was renovated from its original configuration to add approximately 2,100 sq.ft. of floor space. The addition to the home was constructed with 6” wall studs while the existing portion of the home was constructed with 4” wall studs. The insulation was upgraded to R-14 blown fiberglass throughout the home. The heating system and appliances were also upgraded to qualify the home for the ENERGY STAR Program. Both the new addition and the existing building were simulated in REM/Rate. However, the existing home construction did not exceed energy code and no credit was taken for this part of the home when simulating project impacts.

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period prior to and following the renovation of the home. Through discussions with the home owner it was determined that renovations began in the Spring of 2007 and were completed in February of 2008. A pre and post renovation analysis was not possible due to the lack of sufficient data from the pre-renovation period.

The annual average gas consumption (Total Annual Therms) was calculated using only the previous one year’s utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[3]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

Table 2 shows the average annual space heating, domestic hot water (DHW), and appliance used in the home.

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space heating	661
Domestic hot water	305.2
Lighting & appliances (less DHW)	130.8
Total	1097

The average summer therms were equal to the average therm usage during the months of June, July, and August. It was taken that the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis. Table 3 presents the REM/Rate simulation outputs.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1818	905	50%
Heating (kWh)	134	103	23%
Water Heating (Therms)	164	124	24%

Table 4 below outlines the variables that were verified during site visits:

[3] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Table 4: REM/Rate Simulation Outputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[4]
Annual occupied hours (hrs/year)	Typical	Typical	Typical	Typical
Floor area (sq.ft.)	3,855	3,855	3,855	3,855
Number of occupants	3	3	3	3
Occupancy schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of thermostats	2	2	2	2
Occupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	68°F
Unoccupied heating temperature setpoint (F)	68°F	68°F	62°F	63°F
Occupied cooling temperature setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied cooling temperature Ssetpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation rate (exhaust only, cfm)	198 cfm (14 hr/day)	198 cfm (14 hr/day)	198 cfm (14 hr/day)	198 cfm (14 hr/day)[5]
Space heating boiler efficiency	78% AFUE	85% AFUE	95% AFUE	95% AFUE
Domestic hot water heater efficiency	60% EF	81% EF	77%EF	77%EF
Ceiling UA (Btuh/F)	59.8	78.2	-	78.2
Above grade walls UA (Btuh/F)	323.4	298.1	-	298.1
Windows and doors (Btuh/F)	250.1	191.6	-	191.6
Floors over garage (Btuh/F)	13.2	9.7	-	9.7
Floors over ambient (Btuh/F)	6.2	4.6		4.6
Floors over uncoditioned crawl space (Btuh/F)	21.7	16.0		16.0

[4] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

[5] Simulation ventilation rate has automatically been set to 133 cfm by the software to meet the requirements of ASHRAE 62.2.

Basement walls UA (Btuh/F)	65.9	70.8	-	70.8
Window U-Factor (Btuh/ft2F)	0.4	0.304	-	0.304
Skylight U-Factor (Btuh/ft2F)	0.750	0.450		0.450
Overall UA (Btuh/F)	747.7	679.9	-	679.9
Dishwasher EF	0.46	0.46	-	0.46
Clothes dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot water use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating temperature setpoints were as shown in table 5.

Table 5: Temperature Setback Schedules

Space Name	Occupied Setpoint (°F)	Occupied Setpoint Hours	Unoccupied Setpoint (°F)	Unoccupied Setpoint Hours
1st Flr	68°F	3:45 PM to 8:00 AM, weekdays	62°F	All other times
2nd Flr	68°F	3:45 PM to 8:00 AM, weekdays	62°F	All other times

On average, the occupied heating setpoint was equal to 68°F and the unoccupied setpoint was equal to 62°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

From discussions with the homeowner the width of the wall insulation in the new portion of the home was verified to be 5 ½" and 3.5" in the existing portion of the home. A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was too low to provide accurate heat flux readings across the building envelope. Pictures taken on-site (figure 1) verified that the roof insulation was installed as specified in the program application.

Figure 1: Roof Insulation

Boiler Efficiency

A spot measurement of the boiler efficiency was not able to be performed due to a lack of access to the flue stack. In addition, the outdoor ambient air temperature was high enough to preclude the need for heating in the home. In lieu of the lack of a spot boiler efficiency measurement the manufacturer rated efficiency, of 95% AFUE, was entered into REM/Rate for the purpose of the evaluation.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing ENERGY STAR qualified dishwashers and clothes washers. Clothes that are washed with ENERGY STAR washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the ENERGY STAR Clothes Washer and Dishwasher savings calculators[6] and were found to be 1.6 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

[6] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMtbu)	Savings (MMbtu)	% Savings
Heating	134	67	67.5	50%
DHW	40	31	9.8	24%
Appliances	4.9	3.3	1.6	33%
Total	180	101	79.0	44%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- ❑ Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- ❑ Performed spot measurements of space heating boiler efficiency and space temperature
- ❑ Window make and model number was verified to be double paned windows
- ❑ Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- ❑ Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model
Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot

Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[7], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 8,303 gallons/yr[8]. This equates to $72 in annual water and sewer charge savings.

[7] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[8] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 129%.The *ex post* impact algorithm used end-use specific percent savings values outputs from REM/Rate to calculate the space heating and domestic hot water impacts. The *ex ante* savings algorithm used the stated HERS score for the home to calculate an overall percent savings that accounted for both electric and gas impacts in the home. Table 7 summarizes the gas and electric $/year savings from the *ex ante* REM/Rate file as compared to a HERS reference home (reference HERS score = 80). Although this isn't the same baseline used in *ex ante* calculations, this data is easily output by REM/Rate and illustrates the pitfalls of using the total percent savings for the home to estimate the gas impacts for the project.

Table 7: REM/Rate Outputs: HERS Reference Home vs. As-Built Home

Annual End Use Consumption	HERS Reference Home	As-Built Home	% Savings
Natural Gas ($/yr)	3371	2040	39%
Electric ($/yr)	2665	2343	12%
Total ($/yr)	6036	4383	27%

The relatively low electric percent savings neutralize the high gas impacts when calculating the total percent savings for this project. This drives the *ex ante* percent savings value down, resulting in an underestimate of the gas impacts for the project.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the ENERGY STAR Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	3,855 sq.ft.
Building predominant year of construction	2007

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/16/2010
Draft site report completion date	5/11/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES44

4/29/2010

SUMMARY INFORMATION

Project ID	ES44		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Duplex, Single Unit		
Customer Business/Product	Single family home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	38.0	-
		Evaluated	-	43.7	-
		Realization Rate	-	1.2	-
2	Domestic Hot Water Heating	Reported	-	26.0	-
		Evaluated	-	7.6	-
		Realization Rate	-	0.3	-
3	Appliances	Reported		-	
		Evaluated		1.06	
		Realization Rate		-	
Total		Reported	-	64.0	$1,750
		Evaluated	-	52.4	-
		Realization Rate	-	0.82	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	841	404	52%
Heating (kWh)	369	43	88%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	1826	1826	1826	1826
Number of windows	10	10	10	10

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	65°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	143 cfm (8 hr/day)	143 cfm (8 hr/day)	143 cfm (8 hr/day)	143 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating temperature setpoints were as follows:

Table 4: Temperature Setback Schedules

Space Name	Occupied Setpoint (°F)	Occupied Setpoint Hours	Unoccupied Setpoint (°F)	Unoccupied Setpoint Hours
1st Flr Common Areas	68°F	8:30 AM to 10:00 AM PM, all days	65°F	All other times
2nd flr	68°F	8:30 AM to 10:00 AM PM, all days	65°F	All other times

On average, the daytime heating setpoint was equal to 68°F and the nighttime setpoint was equal to 65°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8". Removing the door framing (1"), sheetrock (1/2"), and strapping (1/2" x 2), resulted in an estimated wall thickness of 5 ½", which corresponds to the width of a typical stud wall with 2 x 6" construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	33°F

[2] Based on AHRI Standard BTS-2000 "Method to Determine Efficiency of Commercial Space Heating Boilers"

Exhaust Temperature	132°F
% O_2	6.7%
% CO_2	8%
Ratio CO/CO_2	0.0000

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 87.4%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	84.1	40.4	43.7	52%
DHW	11.9	4.3	7.6	35%
Appliances	3.2	2.2	1.1	-
Total	99.2	46.9	52.4	53%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,470 gallons/yr[5]. This equates to $26 in annual water and sewer charge savings.

[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 82%. The *ex post* impact is lower than the *ex ante* impact due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	1,826 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES45

4/29/2010

SUMMARY INFORMATION

Project ID	ES45
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Townhouse
Customer Business/Product	Townhouse

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	40	-
		Evaluated	-	52.4	-
		Realization Rate	-	1.3	-
2	Domestic Hot Water Heating	Reported	-	27	-
		Evaluated	-	10.9	-
		Realization Rate	-	0.4	-
3	Appliances	Reported		-	
		Evaluated		1.5	
		Realization Rate		-	
Total		Reported	-	67	$1,750
		Evaluated	-	64.8	-
		Realization Rate	-	0.97	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. Measures Included In The Evaluation

2.1. Space Heating, Domestic Hot Water, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced

in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1024	500	51%
Heating (kWh)	68	50	26%
Water Heating (Therms)	226	117	48%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Floor area (sq.ft.)	2,676	2,676	2,676	2,676
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	72°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	72°F	68°F

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	-	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	-	78.5°F
Ventilation Rate(exhaust only, cfm)	54 cfm (12 hr/day)	541 cfm (12 hr/day)	54 cfm (8 hr/day)	54 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	192.2	196.5	-	196.5
Windows and Doors (Btuh/F)	108	79.2	-	79.2
Slab Floor (Btuh/F)	2.0	1.1	-	1.1
Floors Over Garage (Btuh/F)	8.9	6.6	-	6.6
Basement Walls (Btuh/F)	13.8	21		21
Window U-Factor (Btuh/ft2F)	0.4	0.31	-	0.31
Overall UA (Btuh/F)	354.9	334.9	-	334.9
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint was 72°F at all times in the home. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer's documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer's rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[2] and were found to be 1.5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	102	50	52.4	51%
DHW	23	12	10.9	48%
Appliances	4.8	3.4	1.5	-
Total	130	65	64.8	50%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs

[2] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

were overridden by program defaults to run this simulation, including the temperature setpoints of the home.

- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[3], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _30_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 6,336 gallons/yr[4]. This equates to $69 in annual water and sewer charge savings.

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[3] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[4] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area. http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 97%. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area or the number of occupants in the home into account. Therefore, in a home with a small floor area and only a few occupants, like the one evaluated here (2,447 sq.ft. and three occupants), both the baseline and as-built space heating energy are likely to be lower than specified in *ex ante* calculations, resulting in lower impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	No utility bills available.
Total building floor area affected by retrofit *(skip for process measures)*	2,447 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	3/26/2010
Draft site report completion date	4/28/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES46

4/29/2010

SUMMARY INFORMATION

Project ID	ES46		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Duplex, Single Unit		
Customer Business/Product	Single family home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager	n/a		
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	41.0	-
		Evaluated	-	70.2	-
		Realization Rate	-	1.7	-
2	Domestic Hot Water Heating	Reported	-	28.0	-
		Evaluated	-	3.5	-
		Realization Rate	-	0.1	-
3	Appliances	Reported		-	
		Evaluated		0.5	
		Realization Rate		-	
Total		Reported	-	69.0	$1,750
		Evaluated	-	74.2	-
		Realization Rate	-	1.1	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for 2306 Depeyster Drive. However, this site adds a finished basement and hence is not equipped with the radiant heat zones.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (17 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1246	544	56%
Heating (kWh)	546	287	47%
Water Heating (Therms)	79	44	44%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	2938	2938	2938	2938
Number of windows	10	10	10	10
Number of Occupants	1	1	1	1
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	3	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	212 cfm (8 hr/day)	212 cfm (8 hr/day)	212 cfm (8 hr/day)	212 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	17 Gal/day	-	-	17 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 71°F. However, when simulating comparisons between the as-built home and a home built to comply with the New York State Energy Conservation Construction Code (NYSECCC), REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was ~5°F, which is too low to provide accurate heat flux readings across the building envelope. Pictures taken on-site verified that the roof insulation was installed as specified in the program application.

Figure 1: Photo of Roof Insulation

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 4: Flue Gas Analysis

Variable	Value
Inlet Temperature	54°F

[2] Based on AHRI Standard BTS-2000 "Method to Determine Efficiency of Commercial Space Heating Boilers"

Exhaust Temperature	108°F
% O_2	4.4%
% CO_2	9.3%
Ratio CO/CO_2	0.0000

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 88.8%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be .5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMBtu)	As-built Energy Use (MMBtu)	Savings (MMBtu)	% Savings from Rem/Rate
Heating	124.6	54.4	70.2	56%
DHW	7.9	4.4	3.5	44%
Appliances	1.6	1.1	0.5	-
Total	134	60	74.2	55%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 2,735 gallons/yr[5]. This equates to $13 in annual water and sewer charge savings.

[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 108%. The *ex post* impact is higher than the *ex ante* impact due to the limitations of the REM/Rate software to account for all differences between the site and the baseline home. Changes in temperature setpoints and hot water use will also increase the gas impact seen at the site. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (2,938 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	2,398 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010

Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES47

4/23/2010

SUMMARY INFORMATION

Project ID	ES47		
Program Being Evaluated			
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Duplex, Single Unit		
Customer Business/Product	Single family home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager	n/a		
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	42.0	-
		Evaluated	-	59.2	-
		Realization Rate	-	1.4	-
2	Domestic Hot Water Heating	Reported	-	29.0	-
		Evaluated	-	3.4	-
		Realization Rate	-	0.1	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	71.0	$2,000
		Evaluated	-	63.6	-
		Realization Rate	-	0.9	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy (1/2009) through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	523
DHW	61.6
Lighting & Appliances (Less DHW)	26.4
Total	611

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1260	591	53%
Heating (kWh)	552	65	88%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	EnergyStar Reference Home	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	2398	2398	2398	2398
Number of windows	9	10	10	10
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	66°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	66°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F

[2] The use of defaults to run the EnergyStar comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	183 cfm (8 hr/day)	183 cfm (8 hr/day)	183 cfm (8 hr/day)	183 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF[3]
Exterior wall thickness (check near door)	n/a	n/a	5 ½"	5 ½"
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 66°F and was increased only when needed. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

[3] Energy Factor reduced according to the following equation, assuming 35% reduction in water use: http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Volumetric_Hot_Water_Savings_Guidelines.pdf

Modified Energy Factor (EF) = Rated Energy Factor x [Rated Recovery Efficiency /(Rated Recovery Efficiency - % Water Reduction x Rated Energy Factor)] = (0.85 + [0.92 / (0.92 – 0.18 x 0.85)] = 1.02 = Modified EF

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exteriors walls of the site.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [4] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	39°F
Exhaust Temperature	182°F
% O_2	5.1%
% CO_2	8.9%
Ratio CO/CO_2	0.0002

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 86.5%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer’s literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results

[4] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[5] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	112	52	59	53%
DHW	10	6	3	35%
Appliances	4	2.64	1.06	-
Total	125	61	64	51%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a NYSECCC reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home. Additionally, the program uses defaults to define the domestic hot water and appliance loads, not the true as-built loads, which leads to uncertainty in the calculated appliance energies.
- Evaluators were not able to access the interior walls and roof of the home, giving rise to some uncertainty about the quality of the installed insulation. Similarly, it was not feasible to perform blower door tests to verify the infiltration level in the home.

[5] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[6], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 30 %

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[7]. This equates to $26 in annual water and sewer charge savings.

[6] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Water reductions calculated based on typical home occupancy patterns and flow rates stated in: http://www.drinktap.org/consumerdnn/Home/WaterInformation/Conservation/WaterUseStatistics/tabid/85/Default.aspx and http://www.puc.state.tx.us/electric/projects/22241/22241arc/121300petition.pdf

[7] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 90%. The *ex post* impact is lower than the *ex ante* impact due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—.
Total building floor area affected by retrofit *(skip for process measures)*	2,398 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/24/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES48

4/23/2010

SUMMARY INFORMATION

Project ID	ES48
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Duplex, Single Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager	n/a		
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	43.0	-
		Evaluated	-	62.7	-
		Realization Rate	-	1.5	-
2	Domestic Hot Water Heating	Reported	-	30.0	-
		Evaluated	-	10.7	-
		Realization Rate	-	0.4	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	73.0	$2,000
		Evaluated	-	74.5	-
		Realization Rate	-	1.0	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy (1/2009) through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	581
DHW	196
Lighting & Appliances (Less DHW)	84
Total	861

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1260	606	52%
Heating (kWh)	552	320	42%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	EnergyStar Reference Home	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	2398	2398	2398	2398
Number of windows	9	10	10	10
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F

[2] The use of defaults to run the EnergyStar comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	229 cfm (8 hr/day)	229 cfm (8 hr/day)	229 cfm (8 hr/day)	229 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF[3]
Exterior wall thickness (check near door)	n/a	n/a	5 ½"	5 ½"
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. On average, the heating setpoint was equal to 68°F and was increased only when needed during the night. However, when simulating comparisons between the as-built home and a home built to comply with the New York State Energy Conservation Construction Code (NYSECCC), REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

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[3] Energy Factor reduced according to the following equation, assuming 35% reduction in water use: http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Volumetric_Hot_Water_Savings_Guidelines.pdf

Modified Energy Factor (EF) = Rated Energy Factor x [Rated Recovery Efficiency /(Rated Recovery Efficiency - % Water Reduction x Rated Energy Factor)] = (0.85 + [0.92 / (0.92 – 0.18 x 0.85)] = 1.02 = Modified EF

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exteriors walls of the site.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [4] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	38°F
Exhaust Temperature	126°F
% O_2	4.7%
% CO_2	9.2%
Ratio CO/CO_2	0.0001

The sensible boiler efficiency (equal to $1- L_f$) obtained by inputting the variables into the formula provided was 88.0%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer’s literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results

[4] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[5] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	121	58	63	52%
DHW	30	20	11	35%
Appliances	9	8.4	1	-
Total	161	86	74	46%

Both the high efficiency space heating and domestic hot water systems are expected to result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project. Other electric measures were incentivized with funding from SBC sources and are outside the scope of this evaluation. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a NYSECCC reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home. Additionally, the program uses defaults to define the domestic hot water and appliance loads, not the true as-built loads, which leads to uncertainty in the calculated appliance energies.
- Evaluators were not able to access the interior walls and roof of the home, giving rise to some uncertainty about the quality of the installed insulation. Similarly, it was not feasible to perform blower door tests to verify the infiltration level in the home.

[5] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[6], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 30 %

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[7]. This equates to $26 in annual water and sewer charge savings.

[6] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Water reductions calculated based on typical home occupancy patterns and flow rates stated in: http://www.drinktap.org/consumerdnn/Home/WaterInformation/Conservation/WaterUseStatistics/tabid/85/Default.aspx and http://www.puc.state.tx.us/electric/projects/22241/22241arc/121300petition.pdf

[7] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 102%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (2,398 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	2,398 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	2/24/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES49

4/29/2010

SUMMARY INFORMATION

Project ID	ES49
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Duplex, Single Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted from the scope of this evaluation.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	43.0	-
		Evaluated	-	88.1	-
		Realization Rate	-	2.0	-
2	Domestic Hot Water Heating	Reported	-	30.0	-
		Evaluated	-	4.2	-
		Realization Rate	-	0.1	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	73.0	$2,000
		Evaluated	-	93.4	-
		Realization Rate	-	1.3	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation**
Report	4	$392	**Cost / Incentive**
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42. However, this site adds a finished basement and hence is not equipped with the radiant heat zones.

2.1.1. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1478	597	60%
Heating (kWh)	655	308	53%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	3956	3956	3956	3956

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of windows	10	10	10	10
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	4	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	69°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	69°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	233 cfm (8 hr/day)	233 cfm (8 hr/day)	233 cfm (8 hr/day)	233 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. On average, the heating setpoint was equal to 69°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 4: Flue Gas Analysis

Variable	Value
Inlet Temperature	30°F
Exhaust Temperature	137°F
% O_2	4.9%
% CO_2	9.1%
Ratio CO/CO_2	0.0000

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 87.5%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler

[2] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	148	60	88	60%
DHW	12	8	4	35%
Appliances	3.24	2.18	1.06	-
Total	163	70	93	57%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

were overridden by program defaults to run this simulation, including the temperature setpoints of the home.

- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[5]. This equates to $26 in annual water and sewer charge savings.

[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 128%. The *ex post* impact is higher than the *ex ante* impact due to the limitations of the REM/Rate software to account for all differences between the site and the baseline home. Changes in temperature setpoints and hot water use will also increase the gas impact seen at the site. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (3,956 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	3,956 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010

Plan approval date	n/a
Site visit date(s)	2/12/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES50

4/29/2010

SUMMARY INFORMATION

Project ID	ES50
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Duplex, Single Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	44.0	-
		Evaluated	-	40.7	-
		Realization Rate	-	0.9	-
2	Domestic Hot Water Heating	Reported	-	30.0	-
		Evaluated	-	4.2	-
		Realization Rate	-	.1	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	74.0	$2,000
		Evaluated	-	46.0	-
		Realization Rate	-	0.6	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	830	423	49%
Heating (kWh)	367	48	87%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	1826	1826	1826	1826
Number of windows	10	10	10	10

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	208 cfm (8 hr/day)	208 cfm (8 hr/day)	208 cfm (8 hr/day)	208 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

The site was unoccupied at the time of the evaluation. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 4: Flue Gas Analysis

Variable	Value
Inlet Temperature	30°F
Exhaust Temperature	175°F
% O_2	5.4%
% CO_2	8.8%
Ratio CO/CO_2	0.0002

The sensible boiler efficiency (equal to $1- L_f$) obtained by inputting the variables into the formula provided was 86.4%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer’s literature.

Appliance Gas Use

[2] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	83.0	42.3	40.7	49%
DHW	11.9	7.7	4.2	35%
Appliances	3.2	2.2	1.1	-
Total	98.1	52.2	46.0	47%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 20 %

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[5]. This equates to $26 in annual water and sewer charge savings.

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[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 62%. The *ex post* impact is lower than the *ex ante* impact due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	1,826 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES51

4/29/2010

SUMMARY INFORMATION

Project ID	ES51		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Duplex, Single Unit		
Customer Business/Product	Single family home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	46.0	-
		Evaluated	-	45.1	-
		Realization Rate	-	1.0	-
2	Domestic Hot Water Heating	Reported	-	32.0	-
		Evaluated	-	4.2	-
		Realization Rate	-	0.1	-
3	Other Measures (Clothes Dryers)	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	78.0	$2,000
		Evaluated	-	50.4	-
		Realization Rate	-	0.65	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation**
Report	4	$392	**Cost / Incentive**
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	829	378	54%
Heating (kWh)	367	44	88%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	4380	4380	4380	4380
Floor area (sq.ft.)	1826	1826	1826	1826
Number of windows	10	10	10	10

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Occupants	2	2	2	2
Occupancy Schedule	Half the Year	Half the Year	Half the Year	Half the Year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	130 cfm (8 hr/day)	130 cfm (8 hr/day)	130 cfm (8 hr/day)	130 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. On average, the heating setpoint was equal to 70°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 4: Flue Gas Analysis

Variable	Value
Inlet Temperature	34°F
Exhaust Temperature	175°F
% O_2	5.4%
% CO_2	8.8%
Ratio CO/CO_2	0.0002

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 86.5%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer’s literature.

[2] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 5.

Table 5: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	83	38	45	54%
DHW	12	8	4	35%
Appliances	3	2	1	-
Total	98	48	50	51%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.

- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,477 gallons/yr[5]. This equates to $27 in annual water and sewer charge savings.

[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 65%. The *ex post* impact is lower than the *ex ante* impact due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	1,826 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/23/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES52

4/23/2010

SUMMARY INFORMATION

Project ID	ES52		
Program Being Evaluated			
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Townhouse, End Unit		
Customer Business/Product	Single family home		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure level and represent the anticipated savings over a HERS reference building.

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	47.0	-
		Evaluated	-	108.4	-
		Realization Rate	-	2.3	-
2	Domestic Hot Water Heating	Reported	-	33.0	-
		Evaluated	-	10.3	-
		Realization Rate	-	.3	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	80.0	$2,000
		Evaluated	-	119.7	-
		Realization Rate	-	1.5	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42. However, this site adds a finished basement and hence is not equipped with the radiant heat zones.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy (5/2008) through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	733
DHW	189
Lighting & Appliances (Less DHW)	81
Total	1003

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1614	651	60%
Heating (kWh)	697	348	50%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	EnergyStar Reference Home	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	3956	3956	3956	3956
Number of windows	10	10	10	10
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	4	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78°F

[2] The use of defaults to run the EnergyStar comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	308 cfm (8 hr/day)	308 cfm (8 hr/day)	308 cfm (8 hr/day)	308 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The daytime heating setpoint was 70°F and the nighttime heating setpoint was 65°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be approximately 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was too low to provide accurate heat flux readings across the building envelope. Pictures taken on-site verified that the roof insulation was installed as specified in the program application.

Figure 1: Photo of Roof Insulation

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [3] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of

[3] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	57°F
Exhaust Temperature	176°F
% O_2	4.9%
% CO_2	9.1%
Ratio CO/CO_2	0.0004

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 87.2%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler.Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[4] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

[4] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	181.6	73.3	108.4	60%
DHW	29.2	18.9	10.3	35%
Appliances	9.2	8.1	1.1	-
Total	220.0	100.3	119.7	54%

Both the high efficiency space heating and domestic hot water systems are expected to result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project. Other electric measures were incentivized with funding from SBC sources and are outside the scope of this evaluation. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a NYSECCC reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home. Additionally, the program uses defaults to define the domestic hot water and appliance loads, not the true as-built loads, which leads to uncertainty in the calculated appliance energies.
- Evaluators were not able to access the interior walls and roof of the home, giving rise to some uncertainty about the quality of the installed insulation. Similarly, it was not feasible to perform blower door tests to verify the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[5], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _30_%

[5] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Water reductions calculated based on typical home occupancy patterns and flow rates stated in: http://www.drinktap.org/consumerdnn/Home/WaterInformation/Conservation/WaterUseStatistics/tabid/85/Default.aspx and http://www.puc.state.tx.us/electric/projects/22241/22241arc/121300petition.pdf

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,477 gallons/yr[6]. This equates to $27 in annual water and sewer charge savings.

[6] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 150%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. The calculated *ex post* space heating impact was greater than the *ex ante* value, due largely to higher temperature setpoints and longer hours of occupancy in the as-built home. Conversely, the *ex post* domestic hot water impact was significantly lower than *ex ante* values, due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	3,956 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	3/16/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES53

4/29/2010

SUMMARY INFORMATION

Project ID	ES53
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Duplex, Single Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	47.0	-
		Evaluated	-	67.7	-
		Realization Rate	-	1.44	-
2	Domestic Hot Water Heating	Reported	-	33.0	-
		Evaluated	-	6.9	-
		Realization Rate	-	.21	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	80.0	$3,500
		Evaluated	-	75.6	-
		Realization Rate	-	.95	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	104%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42.

2.1.1. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	842	367	56%
Heating (kWh)	367	41	89%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	1826	1826	1826	1826
Number of windows	10	10	10	10

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	6	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	68°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	63°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	89 cfm (8 hr/day)	89 cfm (8 hr/day)	89 cfm (8 hr/day)	89 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating temperature setpoints were as follows:

Table 4: Temperature Setback Schedules

Space Name	Occupied Setpoint (°F)	Occupied Setpoint Hours	Unoccupied Setpoint (°F)	Unoccupied Setpoint Hours
1st Flr Common Areas	68°F	6:30 PM to 6:30 AM PM, all days	63°F	All other times
2nd flr	68°F	6:30 PM to 6:30 AM PM, all days	63°F	All other times

On average, the occupied heating setpoint was equal to 68°F and the unoccupied setpoint was equal to 63°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	36°F

[2] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

Exhaust Temperature	127°F
% O_2	5.8%
% CO_2	8.5%
Ratio CO/CO_2	0.0001

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 87.7%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	120.0	52.3	67.7	56%
DHW	19.5	12.6	6.9	35%
Appliances	6.5	5.4	1.1	-
Total	145.9	70.3	75.6	52%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[5]. This equates to $26 in annual water and sewer charge savings.

[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 95%. The *ex post* impact is lower than the *ex ante* impact due largely to lower domestic hot water usage in the as-built home than predicted in *ex ante* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	1,826 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES54

4/29/2010

SUMMARY INFORMATION

Project ID	ES54
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Duplex, Single Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Sameer Desai

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	51.0	-
		Evaluated	-	94.5	-
		Realization Rate	-	1.9	-
2	Domestic Hot Water Heating	Reported	-	35.0	-
		Evaluated	-	4.2	-
		Realization Rate	-	0.1	-
3	Appliances	Reported		-	
		Evaluated		1.1	
		Realization Rate		-	
Total		Reported	-	86.0	$2,000
		Evaluated	-	99.8	-
		Realization Rate	-	1.2	-

1.1. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.2. Budget

Task	Hours	Cost Including Expenses
M&V Plan	4	$392
On site M&V	16	$2,068

Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42. However, this site adds a finished basement and hence is not equipped with the radiant heat zones.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1627	682	58%
Heating (kWh)	705	354	50%
Water Heating (Therms)	119	77	35%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	3956	3956	3956	3956
Number of windows	10	10	10	10
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	4	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	67°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	65°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	271 cfm (8 hr/day)	271 cfm (8 hr/day)	271 cfm (8 hr/day)	271 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating temperature setpoints were as follows:

Table 4: Temperature Setback Schedules

Space Name	Occupied Setpoint (°F)	Occupied Setpoint Hours	Unoccupied Setpoint (°F)	Unoccupied Setpoint Hours
1st Flr Common Areas	68°F	6:30 AM to 11:15 PM, all days	65°F	All other times
2nd flr	65°F	10 AM to 10 PM, all days	65°F	All other times
Basement	65°F	7 AM to 10 PM, all days	65°F	All other times

On average, the daytime heating setpoint was equal to 67°F and the nighttime setpoint was equal to 65°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was visually verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

A review with the infrared camera revealed that there were no obvious areas of missing or inadequate insulation in the exterior walls.

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [2] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimated using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of

[2] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 5: Flue Gas Analysis

Variable	Value
Inlet Temperature	30°F
Exhaust Temperature	179°F
% O_2	5.8%
% CO_2	8.5%
Ratio CO/CO_2	0.0003

The sensible boiler efficiency (equal to $1- L_f$) obtained by inputting the variables into the formula provided was 86.2%. An additional improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	162.7	68.2	94.5	58%
DHW	11.9	7.7	4.2	35%
Appliances	3.2	2.2	1.1	-
Total	178	78	100	56%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,476 gallons/yr[5]. This equates to $26 in annual water and sewer charge savings.

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[4] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimate based on average rates from Cortlandt town website. Sewer rates were not included in this cost. http://www.townofcortlandt.com/Cit-e-Access/webpage.cfm?TID=20&TPID=2504

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 116%. The *ex post* impact is higher than the *ex ante* impact due to the limitations of the REM/Rate software to account for all differences between the site and the baseline home. Changes in temperature setpoints and hot water use will also increase the gas impact seen at the site. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (3,956 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	3,956 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010

Plan approval date	n/a
Site visit date(s)	2/11/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES55

4/29/2010

SUMMARY INFORMATION

Project ID	ES55
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Townhouse, End Unit
Customer Business/Product	Single family home

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Sameer Desai
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Cortlandt Manor, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	51	-
		Evaluated	-	91.8	-
		Realization Rate	-	1.8	-
2	Domestic Hot Water Heating	Reported	-	35	-
		Evaluated	-	5.6	-
		Realization Rate	-	0.16	-
3	Appliances	Reported		-	
		Evaluated		2.1	
		Realization Rate		-	
Total		Reported	-	86.0	$2,000
		Evaluated	-	99.5	-
		Realization Rate	-	1.1	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses

M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	181%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES42. However, this site adds a finished basement and hence is not equipped with the radiant heat zones.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

Table 2: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	654
DHW	106.4
Lighting & Appliances (Less DHW)	45.6
Total	806

Where, the average summer therms were equal to the average therm usage during the months of June, July, and August. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in September. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 3: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	1611	670	58%
Heating (kWh)	705	353	50%
Water Heating (Therms)	119	78	34%

The table below outlines the variables that were verified during site visits:

Table 4: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Annual Occupied Hours (hrs/year)	Typical	8760	8760	8760
Floor area (sq.ft.)	3956	3956	3956	3956
Number of windows	27	27	27	27
Number of Occupants	2	2	2	2
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats & Locations	n/a	n/a	4	n/a
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	65°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F

[2] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	83.5°F
Ventilation Rate(exhaust only, cfm)	308 cfm (8 hr/day)	308 cfm (8 hr/day)	308 cfm (8 hr/day)	308 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92% annual average	92% annual average
Domestic Hot Water Heater Efficiency	60% EF	85% EF	85%EF	85%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	62.3	62.1	62.1	62.1
Above Grade Walls UA (Btuh/F)	308.8	237.5	237.5	237.5
Windows and Doors (Btuh/F)	137.7	115.7	115.7	115.7
Slab Floor (Btuh/F)	2.4	1.3	1.3	1.3
Overall UA (Btuh/F)	11.6	5.5	5.5	5.5
Basement Walls UA (Btuh/F)	55.4	54.5	54.5	54.5
Window U-Factor (Btuh/ft2F)	0.4	0.33	0.33	0.33
Dishwasher EF	0.46	0.46	0.46	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating temperature setpoints were as follows:

Table 5: Temperature Setback Schedules

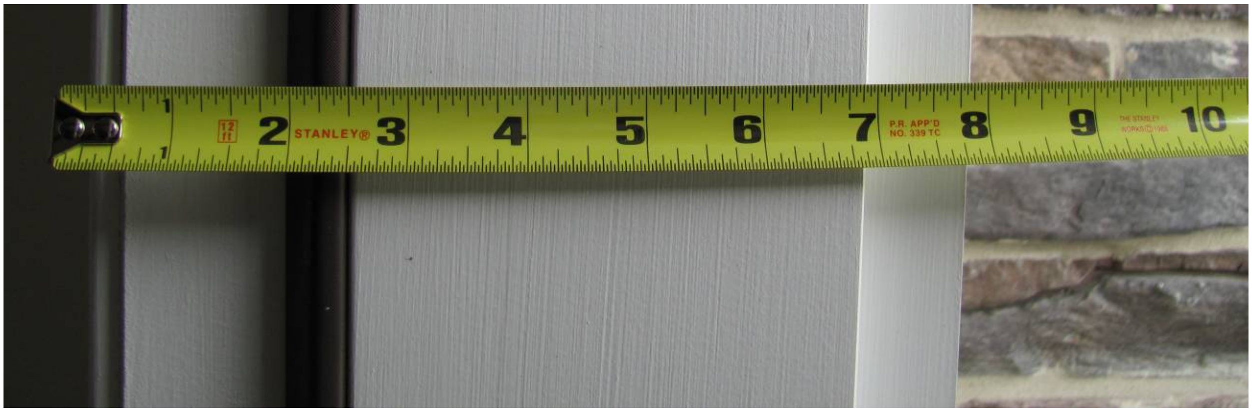
Space Name	Occupied Setpoint (°F)	Occupied Setpoint Hours	Unoccupied Setpoint (°F)	Unoccupied Setpoint Hours
1st Flr Common Areas	72°F	6:30 AM to 11:15 PM, all days	68°F	All other times
1st Flr Bedroom	70°F	All the time	70°F	All the time
2nd flr	70°F	10 AM to 10 PM, all days	62°F	All other times
Basement	67°F	7 AM to 10 PM, all days	62°F	All other times

On average, the daytime heating setpoint was equal to 70°F and the nighttime setpoint was equal to 65°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness



A review with the infrared camera was not possible during site visits as the difference between the inside and outside temperatures was ~5°F, which is too low to provide accurate heat flux readings across the building envelope. Pictures taken on-site verified that the roof insulation was installed as specified in the program application.

Figure 2: Photo of Roof Insulation

Boiler Efficiency

A spot measurement was performed on-site to collect information on the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the exhaust temperature, the temperature of the air supplied for combustion, and the relative humidity of the air supplied for combustion. For gas fired boilers, the following equation was applied to calculate the combustion efficiency of the boiler:

$$\text{Combustion Efficiency} = 1 - L_f + G_L$$

Where L_f is calculated according AHRI Standard BTS-2000 [3] using the % O_2 in the boiler exhaust, % CO_2 in the boiler exhaust, the ratio of CO to CO_2 in the boiler exhaust, the exhaust temperature, and the temperature of the air supplied for combustion, and G_L is the latent energy gained via the condensation of water from the flue gases as they pass over the return water coils. G_L was estimatedd using information spot measured on site and calculations derived from Chapter 18 of the 2005 ASHRAE Handbook of Fundamentals. Values collected during the site visit for these variables are displayed in the following table:

Table 6: Flue Gas Analysis

Variable	Value
Inlet Temperature	65°F
Exhaust Temperature	107°F

[3] Based on AHRI Standard BTS-2000 “Method to Determine Efficiency of Commercial Space Heating Boilers”

% O_2	4.9%
% CO_2	9.2%
Ratio CO/CO_2	0.0001
Return Temperature (°F)	102

The sensible boiler efficiency (equal to 1- L_f) obtained by inputting the variables into the formula provided was 89.1%. Given the estimated return temperature and the spot measured flue temperature, an additional 5.8% to 6.4% improvement in the boiler efficiency could be expected due to water condensing out of the exhaust of the boiler. The overall spot measured boiler efficiency is therefore equal to 94.9%-95.5%. Extrapolating these calculations to estimate the overall boiler efficiency over the course of the year results in an estimated annual average efficiency of 92%, which agrees with the 92% AFUE specified in manufacturer's literature.

Appliance Gas Use

The site has been credited with a 9% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[4] and were found to be 1.1 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 7.

Table 7: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (Mmbtu)	As-built Energy Use (MMbtu)	Savings (MMBtu)	% Savings
Heating	157.1	65.4	91.8	58%
DHW	16.2	10.6	5.6	34%
Appliances	6.7	4.6	2.1	-
Total	180.0	80.6	99.5	55%

[4] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 9% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[5], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 5,470 gallons/yr[6]. This equates to $26 in annual water and sewer charge savings.

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[5] Additional 9% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[6] Estimate based on combined water and sewer rates in the New York City Area. http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 116%. The *ex post* impact is higher than the *ex ante* impact as a result of the use of the actual utility bills to calculate measure impacts. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a large floor area, like the one evaluated here (3,956 sq.ft.), both the baseline and as-built space heating energy are much higher than specified in *ex ante* calculations, resulting in a greater potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	3,956 sq.ft.
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	3/25/2010
Draft site report completion date	4/22/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES56

5/11/2010

SUMMARY INFORMATION

Project ID	ES56		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Townhouse		
Customer Business/Product	Townhouse		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space heating	Reported	-	62	-
		Evaluated	-	44.7	-
		Realization Rate	-	0.72	-
2	Domestic hot water heating	Reported	-	43	-
		Evaluated	-	10.9	-
		Realization Rate	-	0.25	-
3	Appliances	Reported		-	
		Evaluated		1.5	
		Realization Rate		-	
Total		Reported	-	105	$1,750
		Evaluated	-	57.1	-
		Realization Rate	-	0.54	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses
M&V plan	4	$392
On site M&V	16	$2,068

Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (therms)	913	466	49%
Heating (kWh)	613	557	9%
Water heating (therms)	226	117	48%

Table 3 outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Floor area (sq.ft.)	2,447	2,447	2,447	2,447
Number of occupants	3	3	3	3
Occupancy schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of thermostats	3	3	3	3
Occupied heating temperature setpoint (F)	68°F	68°F	75°F	68°F
Unoccupied heating temperature setpoint (F)	68°F	68°F	71°F	63°F
Occupied cooling temperature setpoint (F)	78.5°F	78°F	75°F	78.5°F
Unoccupied cooling temperature setpoint (F)	78.5°F	78°F	75°F	83.5°F
Ventilation rate(exhaust only, cfm)	71 cfm (2 hr/day)	71 cfm (2 hr/day)	71 cfm (8 hr/day)	71 cfm (8 hr/day)
Space heating boiler efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic hot water heater efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½″	5 ½″
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above grade walls UA (Btuh/F)	181.2	187.1	-	187.1
Windows and doors (Btuh/F)	89.2	66.7	-	66.7
Slab floor (Btuh/F)	1.4	1.1	-	1.1
Floors over garage (Btuh/F)	10.6	7.8	-	7.8
Basement walls (Btuh/F)	13.8	25.6		25.6
Window U-factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	326.9	318.9	-	318.9
Clothes dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot water use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were employed in the home. The heating setpoint was 75°F when the home was occupied and 71°F when the home was unoccupied. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using a programmable thermostat with a 68°F heating setpoint and 5°F temperature setback. These were the setpoints modeled in this evaluation.

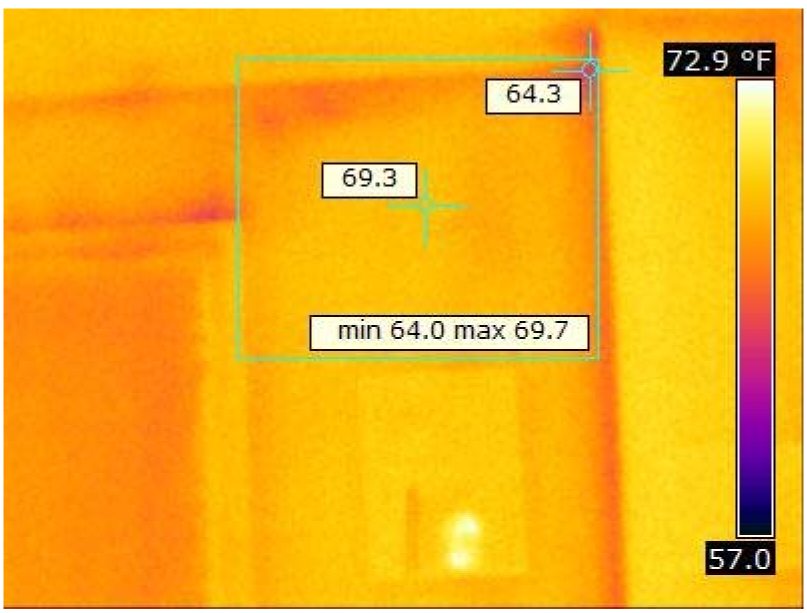
Envelope Properties

The wall thickness was verified to be 8″. Removing the door framing (1″), sheetrock (1/2″), and strapping (1/2″ x 2″), resulted in an estimated wall thickness of 5 ½″, which corresponds to the width of a typical stud wall with 2″ x 6″ construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Pictures taken with an infrared camera indicated interior wall temperatures that were very close to the interior space temperature, indicating a high R-value wall, consistent with construction specifications. The relatively uniform temperatures across the wall surface indicate well installed, continuous insulation, consistent with construction documents. The only cool spots are along the wall joints, where thermal bridging tends to occur.

Figure 2: Interior Wall Surface Temperature



Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer's documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer's rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[2] and were found to be 1.5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 4.

Table 4: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	91	47	44.7	49%
DHW	23	12	10.9	48%
Appliances	5	3	1.5	31%
Total	119	62	57.1	48%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.

[2] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with an 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[3], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 30%

2.1.10. Non-Energy Impacts

High efficiency clothes washers and dishwashers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 6,336 gallons/yr[4]. This equates to $69 in annual water and sewer charge savings.

[3] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home. .

[4] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area. http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 54%. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area or the number of occupants in the home into account. Therefore, in a home with a small floor area and only a few occupants, like the one evaluated here (2,447 sq.ft. and three occupants), both the baseline and as-built space heating energy are likely to be lower than specified in *ex ante* calculations, resulting in lower impacts in *ex post* calculations.

The *ex post* impact algorithm used end-use specific percent savings values output from REM/Rate to calculate the space heating and domestic hot water impacts. The *ex ante* savings algorithm used the stated HERS score for the home to calculate an overall percent savings that accounted for both electric and gas impacts in the home. Table 7 summarizes the gas and electric $/year savings from the *ex ante* REM/Rate file as compared to a HERS reference home (reference HERS score = 80). Although this isn't the same baseline used in *ex ante* calculations, this data is easily output by REM/Rate and illustrates the pitfalls of using the total percent savings for the home to estimate the gas impacts for the project.

Table 5: REM/Rate Outputs: HERS Reference Home vs. As-built Home

Annual End Use Consumption	HERS Reference Home	As-Built Home	% Savings
Natural Gas ($/yr)	1546	805	48%
Electric ($/yr)	1499	1336	11%
Total ($/yr)	3045	2141	30%

The relatively low electric percent savings neutralize the high gas impacts when calculating the total percent savings for this project. This drives the *ex ante* percent savings value down, resulting in an underestimate of the gas impacts for the project.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	2,447 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/26/2010
Draft site report completion date	4/28/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES57

4/30/2010

SUMMARY INFORMATION

Project ID	ES57
Program Being Evaluated	NY Energy Star Homes
Customer Name	
Site Name if Different	
Site Address	
Building or Site Type	Townhouse
Customer Business/Product	Townhouse

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	63	-
		Evaluated	-	48.2	-
		Realization Rate	-	0.77	-
2	Domestic Hot Water Heating	Reported	-	43	-
		Evaluated	-	10.9	-
		Realization Rate	-	0.25	-
3	Appliances	Reported		-	
		Evaluated		3.2	
		Realization Rate		-	
Total		Reported	-	106	$1,750
		Evaluated	-	62.3	-
		Realization Rate	-	0.59	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating, Domestic Hot Water, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced

in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	978	496	49%
Heating (kWh)	-	0	-
Water Heating (Therms)	226	117	48%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Floor area (sq.ft.)	2,676	2,676	2,676	2,676
Number of Occupants	3	3	3	3
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	63°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	63°F	68°F

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Ventilation Rate(exhaust only, cfm)	63 cfm (4 hr/day)	63 cfm (4 hr/day)	63 cfm (8 hr/day)	63 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	192.2	196.5	-	196.5
Windows and Doors (Btuh/F)	108.0	79.2	-	79.2
Slab Floor (Btuh/F)	2.0	1.1	-	1.1
Floors Over Garage (Btuh/F)	8.9	7.6	-	7.6
Basement Walls (Btuh/F)	13.8	21		21
Window U-Factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	354.9	336.0	-	336.0
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint was 63°F at all times. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer's documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer's rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[2] and were found to be 3.2 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 6.

Table 6: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	97.8	49.6	48.2	49%
DHW	22.6	11.7	10.9	48%
Appliances	4.8	3.4	3.2	-
Total	125.2	64.7	62.3	50%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and

[2] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[3], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _30_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 6,336 gallons/yr[4]. This equates to $69 in annual water and sewer charge savings.

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[3] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[4] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area. http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

Overall, the total project realization rate was 59%. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a small floor area, like the one evaluated here (2,676 sq.ft.), both the baseline and as-built space heating energy are lower than specified in *ex ante* calculations, resulting in a lower potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the “ECC of NY” reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	2,676 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/26/2010

Draft site report completion date	4/30/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES58

4/29/2010

SUMMARY INFORMATION

Project ID	ES58		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Townhouse		
Customer Business/Product	Townhouse		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	63	-
		Evaluated	-	17.8	-
		Realization Rate	-	0.28	-
2	Domestic Hot Water Heating	Reported	-	44	-
		Evaluated	-	13.3	-
		Realization Rate	-	0.3	-
3	Appliances	Reported		-	
		Evaluated		1.5	
		Realization Rate		-	
Total		Reported	-	107	$1,750
		Evaluated	-	32.5	-
		Realization Rate	-	0.3	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced

in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	913	441	52%
Heating (kWh)	613	550	10%
Water Heating (Therms)	226	117	48%

Table 3 outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[1]
Floor area (sq.ft.)	2,447	2,447	2,447	2,447
Number of Occupants	3	3	3	3
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	70°F	68°F

[1] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Ventilation Rate(exhaust only, cfm)	61 cfm (2 hr/day)	61 cfm (2 hr/day)	61 cfm (8 hr/day)	61 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	181.2	164.3	-	164.3
Windows and Doors (Btuh/F)	92.4	66.9	-	66.9
Slab Floor (Btuh/F)	1.4	1.1	-	1.1
Floors Over Garage (Btuh/F)	10.6	7.8	-	7.8
Basement Walls (Btuh/F)	13.8	25.6		25.6
Window U-Factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	329.4	296.3	-	296.3
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint was 70°F at all times in the home. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

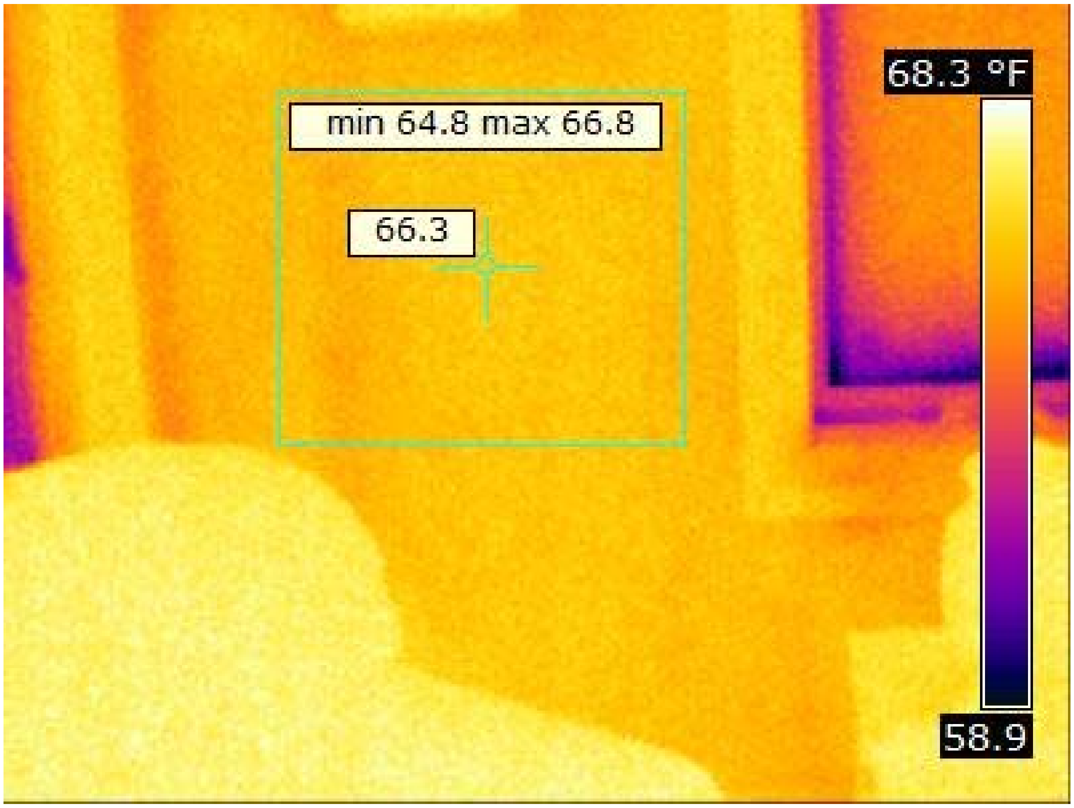
Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Pictures taken with an infrared camera indicated interior wall temperatures that were close to the interior space temperature, indicating a high R-value wall, consistent with construction specifications. The relatively uniform temperatures across the wall surface indicate well installed, continuous insulation, consistent with construction documents. The only cool spots are around the windows, where there appears to be some infiltration along the sill.

Figure 2: Interior Wall Surface Temperature



Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer's documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer's rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[2] and were found to be 1.5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 4.

Table 4: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	34.4	16.6	17.8	52%
DHW	27.5	14.2	13.3	48%
Appliances	4.8	3.4	1.5	0%
Total	66.7	34.2	32.5	49%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.

[2] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

- The *ex post* domestic hot water impact credits the site with a 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[3], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _30_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 6,336 gallons/yr[4]. This equates to $69 in annual water and sewer charge savings.

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[3] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[4] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area. http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 30%. The *ex post* impact is lower than the *ex ante* impact as a result of the low gas use observed in the home's utility bills. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a small floor area, like the one evaluated here (2,447 sq.ft.), both the baseline and as-built space heating energy are lower than specified in *ex ante* calculations, resulting in a lower potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	2,447 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	3/26/2010
Draft site report completion date	4/28/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES59

4/28/2010

SUMMARY INFORMATION

Project ID	ES59		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Townhouse		
Customer Business/Product	Townhouse		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	63	-
		Evaluated	-	25.5	-
		Realization Rate	-	0.4	-
2	Domestic Hot Water Heating	Reported	-	44	-
		Evaluated	-	11.1	-
		Realization Rate	-	0.3	-
3	Appliances	Reported		-	
		Evaluated		4.2	
		Realization Rate		-	
Total		Reported	-	107	$1,750
		Evaluated	-	40.8	-
		Realization Rate	-	0.4	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. Measures Included In The Evaluation

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced

in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

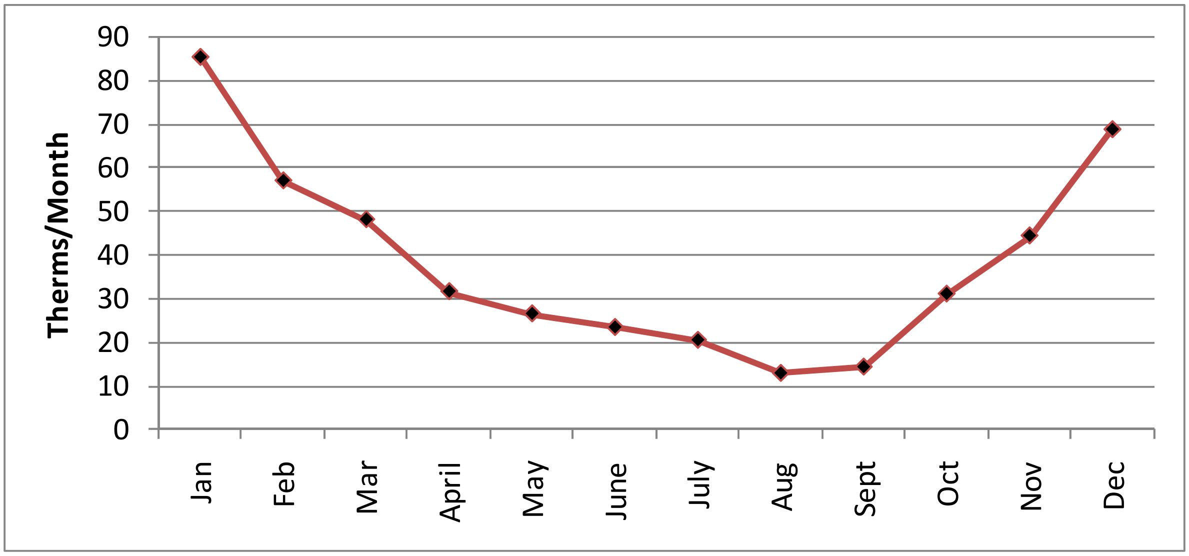
Table 1: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	251
DHW	149
Lighting & Appliances (Less DHW)	64
Total	463

Where, the average summer therms were equal to the average therm usage during the months of June, July, August, and September. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in October. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Figure 1: Average Monthly Gas Use



Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (66 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	912	452	50%
Heating (kWh)	618	550	11%
Water Heating (Therms)	265	152	43%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Floor area (sq.ft.)	2,446	2,446	2,446	2,446
Number of Occupants	4	4	4	4

[2] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	74-75°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	74-75°F	68°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	78°F	78.5°F
Ventilation Rate(exhaust only, cfm)	60 cfm (2 hr/day)	60 cfm (2 hr/day)	60 cfm (8 hr/day)	60 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	181.2	164.3	-	164.3
Windows and Doors (Btuh/F)	92.4	66.9	-	66.9
Slab Floor (Btuh/F)	1.4	1.1	-	1.1
Floors Over Garage (Btuh/F)	10.6	7.8	-	7.8
Basement Walls (Btuh/F)	13.8	25.6		25.6
Window U-Factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	329.4	296.3	-	296.3
Dishwasher EF	0.46	0.46	-	0.46
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	66 Gal/day	-	-	66 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint varied from room to room and was between 74°F and75°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer’s documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer’s rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 4.2 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 4.

Table 4: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (Mmbtu)	As-built Energy Use (MMbtu)	Savings (MMBtu)	% Savings
Heating	50.6	25.1	25.5	50%
DHW	25.9	14.9	11.1	43%
Appliances	6.5	4.5	4.2	-
Total	83.0	44.4	40.8	49%

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with a 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 8,447 gallons/yr[5]. This equates to $92 in annual water and sewer charge savings.

[4] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area. http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 38%. The *ex post* impact is lower than the *ex ante* impact as a result of the low gas use observed in the home's utility bills. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a small floor area, like the one evaluated here (2,446 sq.ft.), both the baseline and as-built space heating energy are lower than specified in *ex ante* calculations, resulting in a lower potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	2,446 sq.ft.
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a

Site visit date(s)	3/26/2010
Draft site report completion date	4/28/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES60

4/30/2010

SUMMARY INFORMATION

Project ID	ES60		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Townhouse		
Customer Business/Product	Townhouse		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	64	-
		Evaluated	-	50.3	-
		Realization Rate	-	0.79	-
2	Domestic Hot Water Heating	Reported	-	44	-
		Evaluated	-	10.9	-
		Realization Rate	-	0.25	-
3	Appliances	Reported	-	-	
		Evaluated	-	1.5	
		Realization Rate	-	-	
Total		Reported	-	108	$1,750
		Evaluated	-	62.7	-
		Realization Rate	-	0.58	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Space Heating and Domestic Hot Water Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures.

2.1.1. Application Description of Baseline

According to program documentation, this project is a new construction home that was built to be an Energy Star qualified home. This baseline building was assumed to have a HERS (Home Energy Rating System) score of 81.3[1].

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

The evaluation baseline was a home built to just meet the requirements of the New York State Energy Conservation Construction Code (NYSECCC).

2.1.3. Seasonable Variability in Schedule and Production

The gas impacts associated with this project are strongly dependent on seasonal weather variations. Heat loss via conduction, convection, radiation, and infiltration from the building envelope was highest in the winter, leading to a higher gas impacts during this period.

2.1.4. Application Description of As-Built Equipment and Operation

The building is classified as a townhouse, end-unit and has four above grade floors (ground floor garage and 1st through 3rd floors occupied). The slab floor is specified with R-10 insulation. The above-grade-wall insulation is rated at a U-value of 0.077 (R-13). The roof insulation is rated a U-value of 0.039 (R-

[1] It is postulated that a HERS score of 81.3 was used as the program baseline to represent a more building built to the New York Energy Conservation Construction Code, which is more stringent than the requirements of an Energy Star reference home (HERS Score of 80).

25). Marvin double paned windows with a U-value of .31 and a SHGC of .30 are used throughout the home.

The heating system consists of a condensing natural gas boiler with a rated AFUE of 92.7%. The building is furnished with one 3-ton split system A/C unit with a seasonal energy efficiency rating (SEERs) of 14. The home is divided into three thermal zones, one per floor, each with their own thermostat. Thermostats in each zone are manually indexed to either heating or cooling mode to meet the comfort needs of the occupants.

Exhaust fans run 8 hours/day at 61 cfm to cycle fresh air into the space.

Domestic hot water is supplied via a 60 gallon indirect fired water heater with a rated energy factor of 81%.

2.1.5. Applicant Energy Savings Algorithms

Building characteristic data was collected by a certified home energy rater and entered into REM/Rate, a building modeling software. This software compares the building, as entered by the rater, to a Energy Star reference building with similar geometry, orientation, and location, and outputs the energy savings over the reference building in the form of a Home Energy Rating Score (HERS).

Information on insulation, window, and door properties were taken from manufacturer's specifications. Infiltration levels were determined using a blower-door test, and ventilation rates were verified through spot measurements. Space heating and domestic hot water boiler efficiencies were taken from manufacturer data. The output from REM/Rate was the Rated HERS score for the home. This value was used with the steps detailed in the example[2] shown in Table 1 to calculate the claimed DHW savings.

A similar algorithm was used to calculate the space heating savings. The only difference is that the base consumption was for space heating, averaged for the region, instead of DHW. Thus the site-specific reported savings is independent of home size.REM

Table 1: Annual Gas Use Algorithm Example

DHW MMBTU Calculations:	Example Calculation
A. Rated HERS Score	93
B. Base HERS Score	81.3
C. Subtract Base from Rated HERS Score (A-B)	11.7
D. Multiply by 5% (C * 5%)	0.585
E. Base DHW consumption for REGION (e.g. NYC)	76.2
F. DHW Mmbtu Savings (D*E)	44.577

[2] Sufficient information was not available to perform these calculations for the home under evaluation. Attempts to run these calculations resulted in DHW and space heating gas savings values that differed from those claimed by NYSERDA in program documents. Therefore, to limit possible confusion the example shown is not specific to this site. The gas savings claimed in NYSERDA program documentation have been taken as the *ex ante* impacts for the purposes of this evaluation.

Baseline DHW by REGION	DHW (MMbtu/yr)
WEST. SOUTHERN TIER	82.5
NYC	76.2
ROCHESTER	82.2
BUFFALO	82.5
SYRACUSE	83.3
ALBANY	83.3
BINGHAMTON	85.5
ST. LAWRENCE/ADIRONDACKS	88.1
LI	76.2
Baseline Space Heating by REGION	**HEATING (MMBtu/yr)**
WEST. SOUTHERN TIER	130.4
NYC	110.2
ROCHESTER	123.6
BUFFALO	130.4
SYRACUSE	120.1
ALBANY	118.8
BINGHAMTON	130.9
ST. LAWRENCE/ADIRONDACKS	137.8
LI	110.2

2.1.6. Evaluation Energy Savings Algorithms

Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (50 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	975	472	52%
Heating (kWh)	-	-	-
Water Heating (Therms)	226	117	48%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[3]
Floor area (sq.ft.)	2,651	2,651	2,651	2,651
Number of Occupants	0	0	0	0
Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	64°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	64°F	63°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	75°F	78.5°F
Ventilation Rate(exhaust only, cfm)	71 cfm (2 hr/day)	71 cfm (2 hr/day)	71 cfm (8 hr/day)	71 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92.7% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	44% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	181.2	187.1	-	187.1
Windows and Doors (Btuh/F)	89.2	66.7	-	66.7
Slab Floor (Btuh/F)	1.4	1.1	-	1.1
Floors Over Garage (Btuh/F)	10.6	7.8	-	7.8
Basement Walls (Btuh/F)	13.8	25.6		25.6
Window U-Factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	326.9	318.9	-	318.9

[3] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	50 Gal/day	-	-	50 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that no temperature setbacks were employed in the home. The heating setpoint was 64°F at all times. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer’s documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer’s rated AFUE was used in this evaluation.

Appliance Gas Use The home was not occupied at the time of the evaluator’s site visit. However, the homeowner anticipated that the home would not remain unoccupied for long. Given this information evaluators performed their domestic hot water analysis under the assumption that the home was occupied by three people, rather than assuming that the domestic hot water load for the home was zero. The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[4] and were found to be 1.5 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project

[4] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 4.

Table 4: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)
Heating	97.5	47.2	50.3
DHW	22.6	11.7	10.9
Appliances	4.8	3.4	1.5
Total	124.9	62.3	62.7

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.7. Data Measurement

Additional information was collected via interviews, inspections, and spot measurements to supplement the analysis outlined in Section 2.1.6. This information is outlined below:

- Verified the installation of the space heating boiler, ventilators, domestic hot water heaters, wall, roof, and floor insulation, and windows.
- Performed spot measurements of space heating boiler efficiency and space temperature
- Window make and model number was verified to be double paned windows
- Took pictures with the infrared camera to capture interior wall temperature and visually inspect continuity of insulation
- Utility bill data was collected

The following equipment was used on-site:

Equipment monitored	Space heat boiler & DHW heater	Wall & roof insulation R-value	Temperature setpoints, windows, appliances, boilers, DHW heater
Parameter measured	combustion efficiency	Wall and air temperature & thickness	Setpoints, make, and model

Measurement equipment	Combustion analyzer	Infrared thermometer, IR camera, tape measure	Camera & checklist
Observation frequency	Spot	Spot	Spot
Metering duration	n/a	n/a	n/a
Accuracy	2%	25%	n/a

2.1.8. Site Sampling Strategy

A site sampling strategy was not required for this site.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with an 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[5] but is not site-specific and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: 30 %

2.1.10. Non-Energy Impacts

High efficiency clothes washers and dishwashers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 6,336 gallons/yr[6]. This equates to $69 in annual water and sewer charge savings.

[5] Additional savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[6] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 58%. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a small floor area, like the one evaluated here (2,651 sq.ft.), both the baseline and as-built space heating energy are lower than specified in *ex ante* calculations, resulting in a lower potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports and to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	2,651 sq.ft.
Building predominant year of construction	2006

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http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf & http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/26/2010
Draft site report completion date	4/30/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

ES61

4/29/2010

SUMMARY INFORMATION

Project ID	**ES61**		
Program Being Evaluated	NY Energy Star Homes		
Customer Name			
Site Name if Different			
Site Address			
Building or Site Type	Townhouse		
Customer Business/Product	Townhouse		

Principal Site Contact			
Title			
Phone			
NYSERDA Project Manager			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	Laurentia Ash
Plan Author	Betsy Ricker

1. PROJECT SUMMARY

This project consists of the construction of a new Energy Star qualified home in Sleepy Hollow, NY. Energy efficiency measures that have been implemented in this home include improvements to the building envelope, heating system, cooling system, domestic hot water system, and space temperature controls. Only measures affecting gas energy use in the home are included in this evaluation. Measures such as space cooling improvements and high efficiency electric appliances were omitted.

Energy savings are reported on a measure-by-measure basis and represent the anticipated savings over a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC).

1.1. Savings

Meas. ID	Measure Name		Electric Impacts (kWh/yr)	Gas Impacts (MMbtu/yr)	Incentive Value ($)
1	Space Heating	Reported	-	64	-
		Evaluated	-	35.6	-
		Realization Rate	-	0.56	-
2	Domestic Hot Water Heating	Reported	-	44	-
		Evaluated	-	12.3	-
		Realization Rate	-	0..28	-
3	Appliances	Reported		-	
		Evaluated		1.0	
		Realization Rate		-	
Total		Reported	-	108	$1,750
		Evaluated	-	48.8	-
		Realization Rate	-	0.45	-

1.2. Measure Sampling

Measure sampling was not required for this site. Only measures resulting in direct gas impacts were included in this evaluation.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V Plan	4	$392	
On site M&V	16	$2,068	
Analysis	8	$784	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	32	$3,636	207%

2. Measures Included In The Evaluation

2.1. Space Heating, Domestic Hot Water, and Appliance Measures

The measures evaluated include improvements to the building envelope, infiltration levels, heating system, domestic hot water system, and space temperature controls. Each of these measures is introduced

in more detail below. Collectively, these measures are designed to result in lower energy use than in a similar building that was built to meet energy code. This evaluation assessed the collective gas energy impacts associated with the implementation of these measures. As a means of reducing redundancy and simplifying the reporting process, Sections 2.1.1 through 2.1.5 and 2.1.7 through 2.1.8 have been omitted from this report, but are detailed for a home built to nearly identical specifications in the report for ES60.

2.1.6. Evaluation Energy Savings Algorithms

The following algorithm was used to evaluate savings for this site:

Utility bills were collected covering the period since the start of occupancy through March 2010. The annual average gas consumption (Total Annual Therms) was calculated using the collected utility bills. The as-built space heating, domestic hot water (DHW), and non-DHW appliance gas uses were broken out of the annual gas use according to the following equations:

Annual Space Heating Gas Use (Therms) = Total Annual Therms – Average Summer Therms x 12

Annual DHW Gas Use (Therms) = Average Summer Therms x 12 x 70%[1]

Annual non-DHW appliance Gas Use (Therms) = Average Summer Therms x 12 x 30%

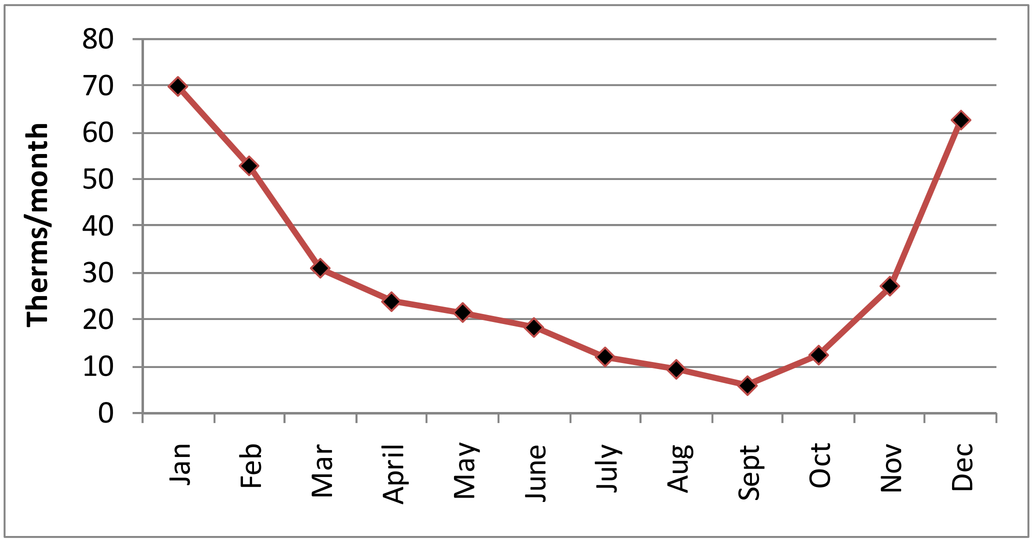
Table 1: Annual Gas Use Breakdown

Billing Period	Gas (Therms)
Space Heating	210
DHW	95
Lighting & Appliances (Less DHW)	41
Total	346

Where, the average summer therms were equal to the average therm usage during the months of June, July, August, and September. Conversations with the homeowner indicated the home's HVAC system was typically indexed from heating to cooling in May and from cooling to heating in October. Therefore, the only gas users in the home during the summer months were the DHW and appliances.

[1] Domestic hot water is estimated to be 70% of the annual appliance gas use, as per: http://www.eia.doe.gov/emeu/recs/recs2005/c&e/detailed_tables2005c&e.html where appliances consume 8.5 MMbtu/year of gas in a typical household (tableap6) and domestic hot water consumes 20.4 MMbtu/year of gas in a typical household (tablewh7).

Figure 1: Average Monthly Gas Use



Evaluators obtained copies of the REM/Rate software files that were used to rate the home from NYSERDA for the purposes of this evaluation. Conditions verified on-site indicated that the building envelope R-value, boiler efficiency, and domestic hot water heater efficiency were all consistent with the values specified in the REM/Rate simulation provided NYSERDA. The percent improvement in space heating and domestic hot water gas use was calculated with the REM/Rate file that was supplied by NYSERDA, which was updated to include the expected domestic hot water usage for the home (33 gallons/day). The baseline for this calculation was a home built to just meet the New York State Energy Conservation Construction Code (NYSECCC). Savings were reported on an end-use basis.

Table 2: REM/Rate Simulation Outputs

Annual End Use Consumption	NYECCC Baseline	As-built	% Savings
Heating (Therms)	975	481	51%
Heating (kWh)	-	0	-
Water Heating (Therms)	185	81	56%

The table below outlines the variables that were verified during site visits:

Table 3: REM/Rate Simulation Inputs

Variable	NYECCC	NYSERDA Claimed	Evaluation Inspection	Evaluation Simulation[2]
Floor area (sq.ft.)	2,651	2,651	2,651	2,651
Number of Occupants	2	2	2	2

[2] The use of defaults to run the NYECCC comparison between a baseline and as-built home results in simulated inputs that differ from those verified on-site.

Occupancy Schedule	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year	7 days per week, 365 days per year
Number of Thermostats	3	3	3	3
Occupied Heating Temperature Setpoint (F)	68°F	68°F	63-66°F	68°F
Unoccupied Heating Temperature Setpoint (F)	68°F	68°F	63-66°F	68°F
Occupied Cooling Temperature Setpoint (F)	78.5°F	78°F	-	78.5°F
Unoccupied Cooling Temperature Setpoint (F)	78.5°F	78°F	-	78.5°F
Ventilation Rate(exhaust only, cfm)	71 cfm (4 hr/day)	71 cfm (4 hr/day)	70 cfm (8 hr/day)	70 cfm (8 hr/day)
Space Heating Boiler Efficiency	78% AFUE	92% AFUE	92.7% AFUE	92.7% AFUE
Domestic Hot Water Heater Efficiency	60% EF	81% EF	81%EF	81%EF
Exterior wall thickness (check near door)	n/a	n/a	5 ½”	5 ½”
Ceiling UA (Btuh/F)	29.9	30.6	-	30.6
Above Grade Walls UA (Btuh/F)	192.2	177	-	177
Windows and Doors (Btuh/F)	108	79.2	-	79.2
Slab Floor (Btuh/F)	2	1.1	-	1.1
Floors Over Garage (Btuh/F)	8.9	7.4	-	7.4
Basement Walls (Btuh/F)	13.8	21		21
Window U-Factor (Btuh/ft2F)	0.40	0.31	-	0.31
Overall UA (Btuh/F)	354.9	316.2	-	316.2
Clothes Dryer	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Oven/Range	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Hot Water Use	33 Gal/day	-	-	33 Gal/day

Thermostat Setpoints

From discussions with the homeowner, it was understood that temperature setbacks were not employed in the home. The heating setpoint varied from room to room and was between 63°F and 66°F. However, when simulating comparisons between the as-built home and an NYECCC reference home, REM/Rate defaults to using non-programmable thermostats with a 68°F heating setpoint. These were the setpoints modeled in this evaluation.

Envelope Properties

The wall thickness was verified to be 8”. Removing the door framing (1”), sheetrock (1/2”), and strapping (1/2” x 2), resulted in an estimated wall thickness of 5 ½”, which corresponds to the width of a typical stud wall with 2 x 6” construction, as specified in construction documents.

Figure 1: Photo of Wall Thickness

Boiler Efficiency

The boiler was not running at the time of the site visit. Manufacturer’s documents indicated a rated AFUE of 92.7%. In the absence of spot measured data, the manufacturer’s rated AFUE was used in this evaluation.

Appliance Gas Use

The site has been credited with an 8% reduction in annual hot water use as a result of installing Energy Star qualified dishwashers and clothes washers. Clothes that are washed with Energy Star washers have lower moisture content when they leave the washer than those washed with conventional washers. This results in a lower load on the dryer, leading to energy savings. The gas impacts associated with the reduced clothes washer, dryer, and dishwasher energy were calculated according to assumptions defined in the Energy Star Clothes Washer and Dishwasher savings calculators[3] and were found to be 1.0 MMbtu/year for this site. These have been incorporated into the evaluated impacts for this project.

Impact Summary

The evaluated impacts were calculated as per the following equations:

Baseline Energy (Therms) = As-built Energy Use / (% savings from REM/Rate)

Annual Impact (Therms) = Baseline Energy – As-built Energy Use

The evaluated impacts are summarized in Table 4.

[3] http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls & http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls

Table 4: Summary of Evaluated Impacts

Evaluated Savings	Baseline Energy (MMbtu)	As-built Energy Use (MMbtu)	Savings (MMbtu)	% Savings
Heating	70.2	34.6	35.6	51%
DHW	21.8	9.5	12.3	56%
Appliances	5.1	4.1	1.0	20%
Total	97.1	48.3	48.8	50%

Both the high efficiency space heating and domestic hot water systems result in electric impacts, although their magnitude is expected to be less than 10% of the total annual MMbtu impact for this project and thus are not in the scope of this evaluation. Other electric measures were incentivized with funding from SBC sources and also are outside the scope. No electric impacts have been included in this evaluation.

2.1.9. Uncertainties

Uncertainties arise in this evaluation as a result of the following:

- The greatest uncertainties arise as a result of the assumptions that were required to draw a comparison between the as-built home and a code reference home. Several of the as-built inputs were overridden by program defaults to run this simulation, including the temperature setpoints of the home.
- It was not feasible to perform blower door tests to verify the infiltration level in the home, leading to some uncertainty in the infiltration level in the home.
- The *ex post* domestic hot water impact credits the site with an 8% reduction in hot water use as a result of high efficiency washers and dishwashers. This number is estimated based on reliable benchmarks[4], but is not site-specific, and therefore has some uncertainty to its value.

Overall expected engineering accuracy including metering accuracy and uncertainties for all measures included in this evaluation: _20_%

2.1.10. Non-Energy Impacts

High efficiency clothes and dish washers were installed at the site. Given typical use profiles for these appliances, total water use (hot and cold) in the home may be reduced by 4,224 gallons/yr[5]. This equates to $46 in annual water and sewer charge savings.

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[4] Additional 8% savings was achieved by lowering domestic hot water use with high efficiency dishwashers and clothes washers. No information was available on showerhead and faucet flow rates, therefore no credit has been taken for these fixtures. Estimated water reductions calculated based on typical home occupancy patterns and EnergyStar appliance calculators from www.energystar.gov. Calculations have been adapted for the number of occupants and typical appliance usage in the home.

[5] Estimated at $ 0.0011/gallon for water and sewer based on 2007 average water cost for citizens of Sleepy Hollow, NY and average sewer costs in the New York City area.

3. Evaluation Report Supplement

3.1. Explanation for Deviation

Overall, the total project realization rate was 45%. The *ex post* impact is lower than the *ex ante* impact as a result of the low gas use observed in the home's utility bills. Although the conditions under which the baseline heating energy use was determined for the *ex ante* impact calculations are not known, it is suspected that they do not take floor area into account. Therefore, in a home with a small floor area, like the one evaluated here (2,651 sq.ft.), both the baseline and as-built space heating energy are lower than specified in *ex ante* calculations, resulting in a lower potential for impacts in *ex post* calculations.

3.2. Deviations from Plan

There were no significant deviations from the evaluation plan.

3.3. Recommendations for Program Designers & Implementers

Evaluators recommend that future energy savings be based on the actual percent savings for each building end-use and that the baseline space heating and domestic hot water values be revisited to ensure that they are representative of the baseline conditions being used to define energy savings for the Energy Star Homes Program. This can be done either by running the REM/Rate software with typical hot water loads and outputting the "ECC of NY" reports to extract the annual domestic hot water and space heating therm use from the simulation or by generating baseline space heating and domestic hot water values that are a function of the floor area of the home rather than using a single value for all baseline homes in a particular region.

3.4. Customer Alert

Evaluators did not have any issues with the site contact.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—r
Total building floor area affected by retrofit *(skip for process measures)*	2,651 sq.ft.
Building predominant year of construction	2006

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http://www.sleepyhollowny.gov/images/Documents/Water%20Department/Water%20Report%202007.pdf &
http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml

3.6. Evaluation Dates

Assignment date	1/25/2010
Plan approval date	n/a
Site visit date(s)	3/26/2010
Draft site report completion date	4/28/2010

3.7. Checklist

Report submission package includes: ☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

LF32

April 3, 2010

Summary Information

Project ID	LF32
Program Being Evaluated	Loan Fund
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Educational

Principal Site Contact	
Title	
Phone	
Email	

NYSERDA Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	
Phone	
Email	

Lead Evaluation Engineer	Yogesh Patil
Report Author	Yogesh Patil

1. PROJECT SUMMARY

The facility is a school with classes from junior kindergarten to grade 8. The school installed two dual-fuel steam boilers through the loan fund program.

1.1. Savings

Table 1: Measure Summary

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Steam boiler replacement	Reported	0	0	79	$266,096
		Evaluated	n/a	n/a	1,527	n/a
		Realization Rate	n/a	n/a	1,933%	n/a

The project documentation did not have any specifics on the total energy savings values. The tracking data provided by NYSERDA indicated a total gas savings of 79.18 MMBtu/yr.

1.2. Measure Sampling

Measure sampling was not necessary. All the gas saving installed equipment was evaluated.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	14	$1,792	
On site M&V	16	$1,978	
Analysis	32	$3,612	**Site Evaluation Cost / Incentive**
Report	24	$2,772	
Total	86	$10,158	1.02%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

Based on the information obtained from discussion with the site staff and that available from the project documentation, prior to installation of the new boilers, the old boilers were gas-fired and in operating condition. The efficiency values for the baseline boilers were not available during the site visit.

The project documentation did not include energy savings calculations.

2.1.2. Evaluation Description of Baseline

Based on the information available in the project documentation, the project is a replacement project where the old gas-fired boilers were replaced with new dual-fuel boilers. The old boilers were installed in 1950s and were manufactured by Cleaver Brooks (210-hp each). The old boilers are considered as the baseline.

Based on discussion with the site staff, natural gas is used at the facility primarily for the boilers (estimated to be more than 95% of total gas bill) with a small amount used by kitchen equipment. The old boiler served the school and the adjacent church. Gas use during the warmer in-session months was 27 to 2,000 therms/month compared to 12,000 to 16,000 therms/month during the primary heating season. Further, regressions of gas use as a function of heating degree-days (HDD) shows gas use trended at or close to zero therms during low or no HDD months.

Old boiler logs were not available to verify the operating characteristics of the boilers. However, since the savings analysis is conducted using billing data, it is assumed that the baseline boiler operating characteristics are inherently considered in the analysis.

2.1.3. Seasonable Variability in Schedule and Production

The boilers are used for space heating and primarily operate during winter months. Based on site observations and discussions with the site staff, the boiler is not estimated to operate during the summer months (June through September).

2.1.4. Application Description of As-Built Equipment and Operation

The school installed two dual-fuel boilers. The school staff only intends to use gas for the boilers and do not anticipate operating the boilers on oil. Both the boilers were found to be identical in specifications. The boilers are manufactured by EASCO Boiler Corporation (Model # ESP-90-S015-OS14 FEB) and are rated at an input of 3,766 MBH.

The boilers are setup in lead/lag configuration and are rotated about every 8 hours. The site staff indicated that only one boiler operates at any given time.

2.1.5. Applicant Energy Savings Algorithms

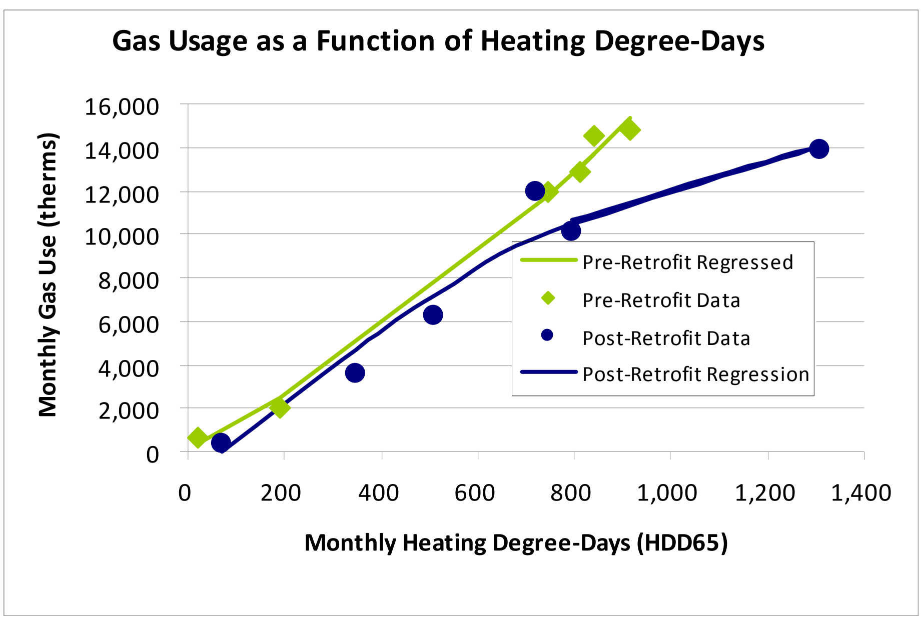
The project documentation did not include energy savings details. The documentation only included the project cost details. The site contact was unable to identify the appropriate source for savings analysis documentation.

2.1.6. Evaluation Energy Savings Algorithms

A spreadsheet based billing analysis was conducted to calculate the energy savings from boilers replacement.

The pre- and post-retrofit billing history was available. The billed gas usage was regressed with corresponding heating degree days (HDDs). The HDDs were calculated using actual ambient temperature data for the region (New York Central Park station) obtained from National Climatic Data Center (NCDC). The regressed data indicated that the billed gas usage correlated well with HDDs. Separate correlations for the pre- and post-retrofit data was obtained.

In order to normalize the data, typical meteorological year 3 (TMY3) weather data was for New York Central Park used to determine the HDDs for winter months. These HDD values were used to calculate the pre- and post-retrofit gas usage using the regression equations. The difference between the pre- and post-retrofit gas usage was the savings and is illustrated below.



The installed boiler efficiency values were obtained using the combustion analyzer, but these values were not used in the savings analysis. The boilers were found to be 81.6% and 82.5% efficient.

2.1.7. Data Measurement Method

The following table presents each variable noted as being measured in the prior section. The measurement equipment was installed and measurements were taken but were not used in the savings analysis.

Equipment monitored	Steam Boilers
Parameter measured	Burner rated capacity, burner combustion fan operating profile, boiler combustion efficiency
Measurement equipment	Combustion analyzer, HOBO amp loggers, Raytek infrared temperature gun
Observation frequency	1 minute for HOBO amp loggers and spot measurements for the rest of the readings
Metering duration	One week
Accuracy	The Raytek IR gun has an accuracy of +/- 3°F to +/- 5°F for target temperature range between -25°F and 73°F. For temperatures above 73°F, the accuracy is +/- 2°F. The HOBO logger has an accuracy of ± 2.5% of absolute reading and the CTs used have an accuracy of ± 1% of full scale. The combustion analyzer accuracy is 0.1%/± 1 % of reading.

2.1.8. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.1.9. Uncertainties

The savings analysis primarily depended on the billing data. Since the boilers are the primary gas users, the assumption that 95% of the total billed gas usage is for boilers seem reasonable.

One of the five post-retrofit months, January 2010, was considerably colder than any other month, pre- or post-retrofit. It had 42% more HDD_{65} than any other month. The post-retrofit regression had an adjusted R^2 of 0.91, however the low number of data points used to develop the post-retrofit HDD-therms relationship curve—one winter, five monthly data points--means that this one extreme temperature month substantially influenced the results. It is possible that this month is not representative of long-term post-results, or that pre-retrofit performance similarly would improve under extreme conditions. Regardless, analysts found no technical reason to presume either of these possibilities is true and left the results as quantified.

Overall expected engineering accuracy including metering accuracy and uncertainties: -25% to + 5%

2.1.10. Non-Energy Impacts

The installed measure is not expected to result in any significant non-energy cost/resource savings/penalties.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The project documentation did not contain the tracking savings analysis or savings estimate. The tracking savings value was obtained from NYSERDA's tracking database. Without any additional information, we assume that the tracking savings were calculated using deemed savings algorithm.

The evaluation savings analysis is based on actual billing history which inherently includes the site operating conditions.

3.2. Deviations from Plan

In the M&V plan we decided to conduct savings analysis using the boiler operating profile along with the pre- and post-retrofit boiler efficiencies. Since the baseline boiler efficiency values were not available, the boilers were responsible for more than 95% of the total billed gas usage, and initial indications were savings between 15% and 20% of billed use, evaluators switched to a billing analysis-based approach.

3.3. Recommendations for Program Designers & Implementers

There were no recommendations identified for program designers and implementers.

3.4. Customer Alert

The site staff was very friendly and promptly provided us with the required data. Based on our communication with the site staff, we do not foresee any issues with future contact for additional work.

3.5. Contextual Data

Natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	76,139
Building predominant year of construction	1846

3.6. Evaluation Dates

Assignment date	12/8/2009
Plan approval date	1/11/2010
Site visit date(s)	3/5/2010
Draft site report completion date	4/5/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☐ PDFs of interview forms (no forms used)
- ☐ Sampling worksheets, if used_(not used)

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

LF33

May 11, 2010

SUMMARY INFORMATION

Project ID	LF33
Program Being Evaluated	New York Energy Smart – Loan Fund
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Commercial/Laundry

Principal Site Contact	
Title	
Phone	
Email	

NYSERDA Representative	
Phone	
Email	

Third Party Contact	
Title	
Company	
Phone	
Email	

Lead Evaluation Engineer	Satyen Moray
Plan/Report Author	Satyen Moray

1. PROJECT SUMMARY

The site is a 9,764 square foot industrial dry cleaning facility. This project was offered a subsidy by NYSERDA on their loan with Citibank for the portion of the costs associated with installing energy efficient equipment at their facility. An energy audit identified numerous measures that had been installed at the facility. The projects included installing high performance T8 lighting, lighting occupancy controls, pipe insulation, air source heat pumps, and replacing old dry cleaning equipment with new equipment that is more efficient and offers a higher production rate than the equipment it replaced.

This gas evaluation is focused on the project associated with the replacement of the dry cleaning equipment. The dry cleaning project involved replacing the existing two 80-lb perc units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit, one 60-lb hydrocarbon unit.

The facility is a commercial dry cleaning operation. The facility operates 11 hours per day for 5 days and occasionally on weekends.

1.1. Savings

ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Install energy efficient dry cleaning equipment	Reported	0*	0	424	$6,363
		Evaluated	n/a	n/a	152	n/a
		Realization Rate	n/a	n/a	36%	n/a

* Reported electricity savings associated with the measure of 181 MWh/yr (PA), 167 MWh/yr (OPC review), and 52 MWh/yr (Approved) exceeds 10% of the gas savings on a Btu basis and thus would have been considered in the scope of this evaluation but NYSERDA already claimed this savings through the SBCIII-funded ECIPP PO8881.

SAIC reviewed the application for accuracy and found the information supplied by the applicant to be accurate. The energy savings details were supplied by the vendor (Columbia Drycleaning Services). SAIC reviewed the pricing for this measure and referenced technical data for the base case and new equipment from the manufacturer's cut sheets for each piece of equipment. SAIC was also provided with utility bills that were used to calculate the measure savings. However, SAIC savings do not match the savings calculations performed by the Columbia Drycleaning Services staff. SAIC analysis estimated gas savings of 424 MMBtu per year and electric savings of 167,344 kWh per year and peak demand reduction of 16.4 kW. The Columbia Drycleaning Services analysis reports gas savings of 985 MMBtu per year with no information presented on the electric savings. NYSERDA's reported savings matches SAIC's lower value. The dry cleaning measure had a reported cost of $346,442.

1.2. Measure Sampling

Since the project involved a single measure, sampling is not necessary to evaluate the savings.

1.3. Budget

<table>
<tr><th>Task</th><th>Hours</th><th>Cost Including Expenses</th><th></th></tr>
<tr><td>M&V plan</td><td>16</td><td>$2,048</td><td></td></tr>
<tr><td>On site M&V</td><td>16</td><td>$3,023</td><td></td></tr>
<tr><td>Analysis</td><td>32</td><td>$4,096</td><td rowspan="2">Site Evaluation Cost / Incentive</td></tr>
<tr><td>Report</td><td>12</td><td>$1,536</td></tr>
<tr><td>Total</td><td>76</td><td>$10,703</td><td>72%</td></tr>
</table>

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	-
Replacement of failed equipment	-
Replacement of working equipment	X
Industrial process expansion	-

The measure involved replacing two existing 80-lb perc (the solvent used is typically tetrachloroethylene, or perchloroethylene, abbreviated "perc") units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit and one 60-lb hydrocarbon unit.

This existing system was composed of two perc systems each with three solvent holding tanks with a total capacity of 215 gallons, a distillation unit of 90 gallons per hour using approximately 6 gpm of chilled water in the process. The two perc units had a combined processing capacity of 160 lbs with an average cycle time of 60 minutes.

The existing hydrocarbon dry cleaning unit has an output of 80 lbs with an average processing time of 90 minutes.

The performance characteristics of the existing perc systems and the hydrocarbon dry cleaning system are listed below:

	Union Perc System	Hoyt (Dry Cleaning)
Output (lbs/cycle)	160	80
Average cycle time (minutes/cycle)	60	90
Production rate (lb/min)	2.7	0.9
Chilled water (gpm) at 50 F	2x6	10
Chilled water (gallons/cycle)	720	900
Steam consumption (lbs/cycle)	2x78	100
Electric consumption (kWh/cycle)	21.9	22.1

The submitted analysis indicated that the existing equipment operated more than 8,580 hours per year.

The project documentation did not have manufacturer’s cut sheet for the old or new dry cleaning equipment models and an internet search did not yield any additional details.

The SAIC review letter (PO 8881) dated April 8, 2008, researched and found that the Union Perc machine cut sheets indicated steam use per cycle of 78 lbs and the Hoyt machine cut sheet indicated steam use per cycle of 100 lbs instead of the 80 lbs used in the analysis.

However, SAIC in their review process had confirmed some of the performance information on these units.

2.1.2. Evaluation Description of Baseline

The baseline for this measure is considered to be the same as described in previous section. Even though the new dry cleaning machines offer slightly higher productivity under the current environment, the current production loads are 73% of the 2007 levels.

2.1.3. Seasonable Variability in Schedule and Production

According to the description in the project documentation and interviews with site contacts, the facility operations are not weather dependent. However general economic conditions have affected the overall business as the facility staff indicated that they are processing less than their production levels several years ago.

2.1.4. Application Description of As-Built Equipment and Operation

The measure involved replacing two existing 80-lb perc units and one 80-lb hydrocarbon unit with one 80-lb and 50-lb perc tandem unit, one 60-lb hydrocarbon unit.

The TD Mach 2.8/2.5 tandem perc system is composed of three sections: two washing and drying sections that utilize one central filtration and distillation section. The first washing and drying section (2.8) is composed of two solvent holding tanks (74 gallons each). The load capacity of each vessel is 80 lbs dry weight. The second washing and drying section (2.5) is composed of two solvent holding tanks (53 gallons each). The load capacity of each vessel is 50 lbs dry weight. Each of these sections is served by individual refrigeration heat pump modules. The third filtration and distillation section is composed of one solvent holding tank (74 gallons) and a steam heated distiller (130 gallons per hour using 4 gpm of chilled water).

The new perc tandem unit has a rated capacity to process 130 lbs in 35 minutes. Depending on the process cycle, the cycle time can on the new perc machines may vary from 10-40 minutes and was verified by us during the site visit. According to the facility staff, the 37-minute cycle time process is the most commonly used setting on these machines.

The new hydrocarbon dry cleaning system (ILSA Model TL HCS 650 N2) is composed of two sections: a washing and drying section that is connected to a filtration and distillation section. The entire system has four solvent tanks. Two of the tanks have a liquid capacity of 74 gallons each, and the other two tanks have a capacity of 42 gallons each. The load capacity is 60 lbs dry weight. The new hydrocarbon dry cleaning unit has a rated capacity to process 60 lbs in 35 minutes. Again depending on the process cycle, the cycle time may vary between 38-48 minutes, which we verified during the site visit. According to the facility staff, the 38-minute cycle time process is the most commonly used setting on these machines.

The performance characteristics of the tandem perc system and the hydrocarbon dry cleaning system are listed below:

	TD MACH 2.8/2.5 Tandem	TL HCS 650
Output (lbs/cycle)	130	60
Avg cycle time (minutes/cycle)	35	60
Production rate (lb/min)	3.7	1.0
Chilled water (gpm) at 50 F	4.6	3
Chilled water (gallons/cycle)	161	180
Steam consumption (lbs/cycle)	99	68
Electric consumption (kWh/cycle)	10.58	12.1

As noted previously, electric savings evaluation is not in scope.

One 30-hp steam boiler supplies steam at 100 psig to the facility. No information on the actual tested boiler system efficiency was provided in the documentation.

The SAIC review letter (PO 8881) dated April 8, 2008, specified that specific performance for the new equipment was requested and was provided based on a test conducted by a Columbia engineer in Germany. The data indicated 99 lbs of steam per cycle for the tandem perc machine (TD MACH 2.8/2.5) and 68 lbs of steam for the hydrocarbon unit (TL HCS 650) compared to the 66 lbs of steam for both the machines indicated in the earlier submitted documents.

One Fulton boiler (Model FB-030-A) generates steam at 100 psig for use in the process and was tested to operate at an efficiency of 74% (6.8% oxygen and 605°F stack temperature). This tested efficiency was used in our analysis.

The original analysis used an estimated efficiency of 70% and system losses of 10% in its calculation.

The equipment operation was confirmed and found to be operational during the site visit.

2.1.5. Measure Life

Specific measure life details are not available for the dry cleaning equipment.

2.1.6. Applicant Energy Savings Algorithms

The original savings reported were calculated using equipment nameplate data as follows:

The steam consumption (lbs and BHP) per cycle for the base case equipment and the new equipment was used. A 10% heat loss factor and a 70% efficiency factor were used to estimate the overall steam load for the old and new equipment options. The general equation for the two options was:

Boiler Load (BHP) = Steam Load (BHP) x Heat Loss Factor (10%) / Efficiency Factor (70%)

Based on the production rates, a production efficiency factor was also determined:

Production Efficiency Factor = New Equipment Production Rate (lbs/min) / Old Equipment Production Rate (lbs/min)

Boiler gas use per hour for the old and new equipment was then calculated using the following equations:

Old Equipment Gas Use (therm/hr): 42 ft^3/hr x Old Boiler Load BHP x 1000 btu/ft^3 / 100,000 Btu/therm

New Equipment Gas Use (therms/hr): 42 ft^3/hr x New Boiler BHP x 1000 btu/ft^3 / 100,000 Btu/therm

The gas use rates for the two options were then multiplied by 8,580 annual operating hours. The new equipment gas use was discounted by production rate at which the laundry is processed. The basis for using a processing rate of 4,750 lbs of linen per hour was not described in the project documentation.

The operating hours were calculated by multiplying the hours per days by number of days per week and weeks per year.

The conventional (baseline) and continuous (as-built) dry cleaning equipment performance data (as described in sections above) was used to calculate the water and steam saved.

The water to be evaporated was calculated and was then multiplied by the difference in baseline and as-built system energy of evaporation to determine the direct gas savings (from water savings). The source for the numbers used in this calculation was not adequately described in the project documentation.

The difference between the baseline and as-built system steam usage per pound of laundry processed was multiplied by the total annual pounds of laundry processed to obtain the savings from reduced steam usage. This value was divided by boiler efficiency.

Electric energy and demand savings were calculated but are considered beyond the scope of this evaluation.

2.1.7. Evaluation Energy Savings Algorithms

The evaluators adjusted the analysis methodology compared to the original algorithms. The key equations used to assess the impact of this measure are:

Steam Use Factor (SUF) = Steam Use Per Cycle (lbs/cycle) / Laundry Load Per Cycle (lbs/cycle)

The above factors are derived from equipment cut sheets.

Max Number of Process Cycles Per Week (MC) (cycles/week) = Equipment Runtime Per Week / Cycle Time

The equipment runtime per week was determined from logged data for the tandem perc unit and the hydrocarbon unit. The cycle time is based on information provided by facility staff and based on field notes.

Actual Number of Process Cycles Per Week (AC) (cycles/week) = MC x Duty Factor

Duty factor is based on logged data. Based on the log data profile, we counted the number of process cycles that occurred during the logging period.

Steam Load Per Week (lbs/week) = AC x Laundry Load Per Cycle x SUF

Production Proration Factor (PRF) = 1.15

This PRF factor was calculated using annual production data provided by the facility staff for the past 3 years and the production data for the month of January 2010. The facility production does increase during the warmer summer/fall months. The facility staff did not track monthly production data with the exception of the January 2010 data that was provided to us based on our earlier request. In 2009, the annual production in the facility was 137,058 units while in the month of January 2010, the production was 9,913 units. Therefore, assuming constant monthly production, the projected annual production using the January 2010 data would be 9,913 units/month x 12 months/yr = 118,956 units/yr. Assuming that 2010 would be similar to 2009, then the production would need to adjusted by a factor = 137,058 / 118,956 = 1.15.

Annual Steam Load (lbs/yr) = Steam Used Per Week x PRF x 52 weeks/yr

Annual Boiler Load (therms/yr) = Annual Steam Load (lbs/yr) x Boiler Delta Enthalpy (Btu/lb) / (Boiler Efficiency x 1000,000 (Btu/therm))

Boiler delta enthalpy was calculated as 1,022 Btu/lb based on feed water entering the boiler at 200°F (168 Btu/lb) and the boiler generating saturated steam at 100 psig (1,190 Btu/lb). The boiler efficiency was tested using a combustion analyzer at 74%.

The table below presents the savings analysis details

HYDROCARBON UNIT ANALYSIS		
	TL HCS 650	**Existing (Hoyt)**
Output (lbs/cycle)	60	80
Average cycle time (minutes/cycle)	38	90
Production rate (lb/min)	1.6	0.9
Steam use - lbs/cycle	68	100
lbs steam / lbs laundry	1.13	1.25
Runtime per week (from logger)	38	
Max no. of cycles	60	
Duty factor	60%	
Actual cycles	36	27
lbs laundry processed per week	2,174	2,174
lbs steam used per week	2,464	2,718
Production proration factor	1.15	1.15
lbs laundry processed per year	130,018	130,018
lbs steam used per year	147,353	162,522
Steam Savings		
Steam (lbs/yr)	15,169	
Steam enthalpy (Btu/lb)	1,190	
Feed water enthalpy (Btu/lb)	168	
Boiler delta enthalpy (Btu/lb)	1,022	
Boiler load (therms/yr)	155	
Boiler efficiency	74%	
Natural gas savings (therms/yr)	209	

PERC UNIT ANALYSIS		
	TD MACH 2.8/2.5 Tandem	**Existing (2 Pieces)**
Output (lbs/cycle)	130	160
Average cycle time (minutes/cycle)	37	60
Production rate (lb/min)	3.5	2.7
Steam use - lbs/cycle	99	156
lbs steam / lbs laundry	0.76	0.98
Runtime per week for 2.8 (from logger)	51	
Runtime per week for 2.5 (from logger)	50	
Average Runtime per week	51	
Max no. of Cycles	82	
Duty factor	70%	
Actual cycles	57	47
lbs laundry processed per week	7,452	7,452
lbs steam used per week	5,675	7,266
Production proration factor	1.15	1.15
lbs laundry processed per year	445,639	445,639
lbs steam used per year	339,371	434,498
Steam Savings		
Steam (lbs/yr)	95,127	
Steam enthalpy (Btu/lb)	1,190	
Feed water enthalpy (Btu/lb)	168	
Boiler delta enthalpy (Btu/lb)	1,022	
Boiler load (therms/yr)	972	
Boiler efficiency	74%	
Natural gas savings (therms/yr)	1,314	

Evaluated Savings

The table below presents the evaluated savings and the overall project realization rate.

Evaluated Savings	
Perc unit savings (therms/yr)	209
Hydrocarbon unit savings (therms/yr)	1,314
Total savings (therms/yr)	**1,523**
Original Application Savings	
Perc unit savings (therms/yr)	2,600
Hydrocarbon unit savings (therms/yr)	1,642
Total savings (therms/yr)	**4,242**
Realization Rate	**36%**

A combination of the factors listed below contributed to the difference between the evaluated savings and the original savings.

- The revised SAIC analysis used 5,100 hours/yr for the old perc unit and 2,700 hours/yr for the old Hoyt machine and 3,600 hours/yr for the new tandem perc units and 2,700 hours/yr for the TL HCS unit while the logged (actual) hours of operation for the new equipment ranges from 2,000 to 2,500 hours per year.
- The boiler efficiency is slightly better than claimed in the original analysis.
- The original analysis did not account for the steam used by the second part of the tandem perc unit. The original analysis only used 66 lbs per cycle while the overall steam for the new tandem perc machine is 99 lbs per cycle.
- The operating cycle times for the new equipment were observed to be slightly higher than predicted in the original analysis.

2.1.8. Data Measurement Method

Complete the table for each variable noted as being measured in the prior section.

Equipment monitored	Boilers	Perc and Hydrocarbon Machine
Parameter measured	Combustion efficiency	Operating hours
Measurement equipment	Combustion analyzer	Interview with the site staff & manufacturer; amp loggers; and onsite observations
Observation frequency	Spot measurement	30 seconds
Metering duration	N/A	2 weeks
Accuracy	± 1 % reading	± 1 % reading

2.1.9. Site Sampling Strategy

Sampling strategy is not necessary for this measure.

2.1.10. Uncertainties

Based on information available in the project documentation, the analysis was conducted for weekly production which was scaled up to determine the annual consumption.

Overall expected engineering accuracy including metering accuracy and uncertainties: 25%

2.1.11. Non-Energy Impacts

After a certain number of cycles, the perc (chemical) used in the dry cleaning process is disposed as a hazardous waste which requires special handling. According to the facility staff, installing the new perc machines significantly reduced the number of hazardous waste barrels generated at the facility as the new machines are able to efficiently recover most of the perc. According to anecdotal information provided by the facility staff, on an average the base case perc machines generated 1,800 lbs of hazardous waste per month and the new perc machines are generating hazardous waste at a rate of 700-800 lbs per month. The waste is typically hauled away in 55-gallon containers at an average price of about $330 per barrel. The density of perc is 13.5 lbs per gallon. However, the waste containers are also filled with filters and other solid waste, so we increased the density by 25%. Table below shows the hazardous waste reduction cost savings that resulted from implementing this project.

	Base case	**Post case**	**Savings**
Average waste produced (lbs/mo)	1,800	750	1,050
Average waste produced (gallons/mo)	133	56	78
Number of barrels per mo	2.4	1.0	1.4
Cost per barrel	$330	$330	
Annual waste disposal cost ($/yr)	$9,592	$3,997	$5,596

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The application savings calculations overestimated due to a number of factors, which are listed below.

- The revised SAIC analysis used 5,100 hours/yr for the old perc unit and 2,700 hours/yr for the old Hoyt machine and 3,600 hours/yr for the new tandem perc units and 2,700 hours/yr for the TL HCS unit while the logged (actual) hours of operation for the new equipment ranges from 2,000 to 2,500 hours per year.
- The boiler efficiency is slightly better than claimed in the original analysis.
- The original analysis did not account for the steam used by the second part of the tandem perc unit. The original analysis only used 66 lbs per cycle while the overall steam for the new tandem perc machine is 99 lbs per cycle.
- The operating cycle times for the new equipment were observed to be slightly higher than predicted in the original analysis.

A combination of these factors resulted in a realization rate of 36%.

3.2. Deviations from M&V Plan

None.

3.3. Recommendations for Program Designers & Implementers

This measure has an efficiency and productivity component that makes the analysis slightly complicated. The evaluators recommend care or precaution when working with these types of measures or installations as they tend to either miss the productivity element of the analysis or the energy element when the intent should be on accurately estimating the impact of both.

3.4. Customer Alert

The site has limited staff availability.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	
Building predominant year of construction	

3.6. Evaluation Dates

Assignment date	1/5/2010
Plan approval date	1/25/2010
Site visit date(s)	2/8/2010, 3/19/2010, 3/31/2010
Draft site report completion date	4/19/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheet

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

L34

June 17, 2010

SUMMARY INFORMATION

Project ID	L34
Program Being Evaluated	Loan Fund, Group A
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Bakery
Customer Business/Product	Baked goods

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Dakers Gowans
Report Author	Dakers Gowans

1. PROJECT SUMMARY

Replace two of three existing ladder ovens with one tunnel oven. New oven includes steam proofer and automated cooling/offloading system. Facility simultaneously switching from fuel oil to natural gas for all fired equipment.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Loan Incentive Value ($)
1	Replace 2 oil-fired ovens with 1 mulit-deck gas-fired tunnel oven. Change 2 existing oil-fired boilers and 1 oil-fired oven to natural gas.	Reported	0	0	5,489	$900,000
		Evaluated			5,489	$900,000
		Realization Rate			1.0	
2		Reported			0	0
		Evaluated				
		Realization Rate				
3		Reported				
		Evaluated				
		Realization Rate				
4		Reported				
		Evaluated				
		Realization Rate				
Total		Reported				
		Evaluated				
		Realization Rate				

1.2. Measure Sampling

No sampling was performed on this site.

1.3. Budget

<table>
<tr><th>Task</th><th>Hours</th><th>Cost Including Expenses</th><th></th></tr>
<tr><td>M&V plan</td><td>2</td><td>$300</td><td></td></tr>
<tr><td>On site M&V</td><td>4</td><td>$600</td><td></td></tr>
<tr><td>Analysis</td><td>6</td><td>$900</td><td rowspan="2">Site Evaluation Cost / Incentive</td></tr>
<tr><td>Report</td><td>4</td><td>$600</td></tr>
<tr><td>Total</td><td>16</td><td>$2,400</td><td><1%</td></tr>
</table>

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#: 1

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	
Replacement of failed equipment	
Replacement of working equipment	X
Industrial process expansion	

The project involves replacement of two of three existing ladder ovens with one tunnel oven. The new oven includes a steam proofer and an automated cooling/offloading system. The facility is simultaneously switching from fuel oil to natural gas for all fired equipment.

The baseline is the total fuel use of the ovens, boilers, and other fuel-oil fired equipment that was in place during the baseline period of November 2007 – July 2008.

2.1.2. Evaluation Description of Baseline

The evaluation used the fuel oil delivery data provided by the applicant and confirmed by the customer during the evaluator's site visit.

Baseline fuel delivery record for June – August 2008 have been extrapolated for annual use and are used to define the baseline condition. Con Edison natural gas bills for 2009 are used to define the performance condition.

2.1.3. Seasonable Variability in Schedule and Production

Fuel demand is correlated to production rates measured in pounds of flour per day. Fuel demand is not weather dependent.

Ovens are reported to be fired ≈ 10 hours/day 5 days/week. The customer verbally stated that production has not varied significantly over the baseline and post-installation periods. The customer was unable to provide flour use data for the post-retrofit period so this report concerning constant load could not be verified.

2.1.4. Application Description of As-Built Equipment and Operation

The project involves replacement of two of three existing ladder ovens with one tunnel oven. The new oven includes a steam proofer and an automated cooling/offloading system. The facility is simultaneously switching from fuel oil to natural gas for all fired equipment.

2.1.5. Applicant Energy Savings Algorithms

Applicant used an engineering analysis approach to calculate ex ante estimates of baseline and post-retrofit performance.

2.1.6. Evaluation Energy Savings Algorithms

The evaluator used fuel oil and natural gas billing records to measure baseline and post-retrofit whole-building fuel use.

2.1.7. Data Measurement Method

Equipment monitored	Billing records
Parameter measured	Billing records
Measurement equipment	Billing records
Observation frequency	Monthly for natural gas, fuel truck deliver for fuel oil
Metering duration	2 months baseline, 12 months post installation
Accuracy	100%
Uncertainty	Completeness of fuel oil records, consumption use dates for fuel oil, accounting for multiple fuel sources

2.1.8. Site Sampling Strategy

No sampling was performed on this site.

2.1.9. Uncertainties

Fuel use is assumed to be a function of production rates measured in pounds of flour per day. The evaluation analysis assumed a constant production rate for the baseline and post-installation periods based on anecdotal accounts offered in interviews with plant personnel during the evaluator's site visit. The customer could not supply actual production records so the steady state assumption cannot be confirmed.

Overall expected engineering accuracy including metering accuracy and uncertainties: 100%.

However the results may not be reliable due to reliance on assumptions about production rates.

2.1.10. Non-Energy Impacts

None

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The evaluated results are the same as the reported results. The billing analysis approach resulted in a 73% savings in fuel use, compared to the reported savings of 40%. Because the production records could not be obtained, the billing records could not be normalized to the throughput of pounds of flour per day. Therefore the billing analysis results are unreliable and the evaluator accepts the calculated ex ante savings as the most accurate available estimates of true performance.

3.2. Deviations from Plan

The evaluator did not use the billing analysis results and the realization rate was left at 1.0.

3.3. Recommendations for Program Designers & Implementers

Require customer to supply the basic data needed to conduct M&V; in this case a full year of baseline oil deliveries and baseline and post-installation monthly flour use.

3.4. Customer Alert

There are no customer alerts.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	Unknown
Building predominant year of construction	Unknown

3.6. Evaluation Dates

Assignment date	January 2010
Plan approval date	NA
Site visit date(s)	March 8, 2010
Draft site report completion date	June 17, 2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files
- ☑ PDFs of interview forms
- ☑ Sampling worksheets, if used

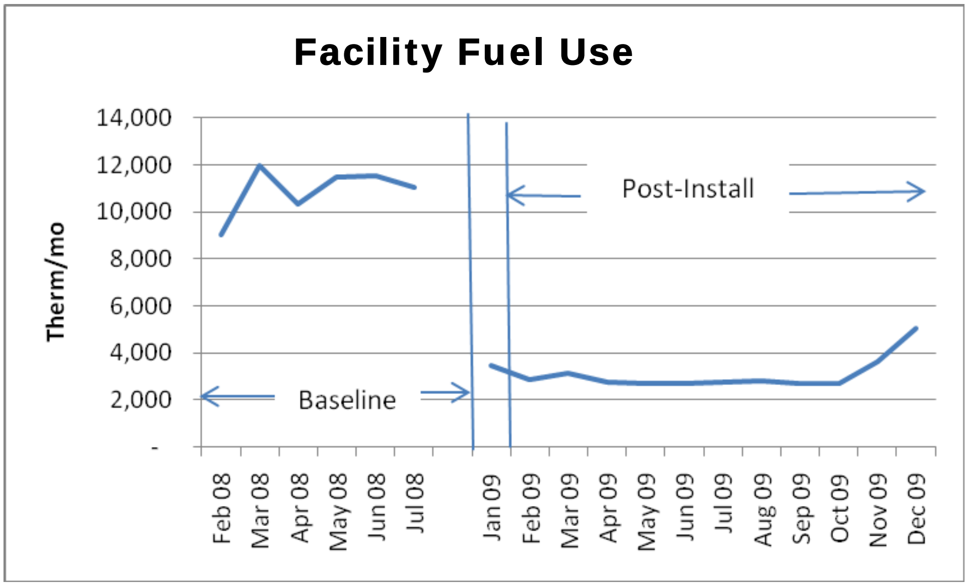
The following billing history data was analyzed for the evaluation review.

Table 1: Con Edison and Adelfi Fuel Oil

Period	From Date	To Date	# days in bill	Oil Purchase (therm)	Gas Use (Therm)	Therm/mo-day
POST INSTALLATION	4/28/2010	5/26/2010	28		3,372	120
	3/30/2010	4/28/2010	29		3,714	128
	3/1/2010	3/30/2010	29		4,528	156
	1/28/2010	3/1/2010	32		5,090	159
	12/29/2009	1/28/2010	30		4,992	166
	11/25/2009	12/29/2009	34		5,562	164
	10/31/2009	11/25/2009	25		3,044	122
	9/25/2009	10/31/2009	36		3,163	88
	8/26/2009	9/25/2009	30		2,695	90
	7/28/2009	8/26/2009	29		2,651	91
	6/26/2009	7/28/2009	32		2,861	89
	5/28/2009	6/26/2009	29		2,616	90
	4/28/2009	5/28/2009	30		2,609	87
	3/30/2009	4/28/2009	29		2,685	93
	2/27/2009	3/30/2009	31		3,148	102
	1/28/2009	2/27/2009	30		3,082	103
	12/8/2008	1/28/2009	51		5,690	112
	1/14/2009	1/28/2009	14		--	112
CONSTRUCTION	12/8/2008	1/14/2009	37		--	112
	8/25/2008	12/8/2008	105		10,157	97
	11/24/2008	12/8/2008	14		--	97
	11/4/2008	11/24/2008	20		--	97
	10/24/2008	11/4/2008	11			97
	9/24/2008	10/24/2008	30			97
	8/25/2008	9/24/2008	30		--	97
BASELINE	7/25/2008	8/25/2008	31	10,324	706	356
	6/25/2008	7/25/2008	30	11,272	243	384
	5/27/2008	6/25/2008	29	10,320	425	371
	4/25/2008	5/27/2008	32	10,639	370	344
	3/27/2008	4/25/2008	29	10,639	544	386
	2/19/2008	3/27/2008	37	10,639	1,297	323
	1/28/2008	2/19/2008	22	10,639	766	518
	12/27/2007	1/28/2008	32	10,639	1,112	367
	11/27/2007	12/27/2007	30	10,639	1,044	389

Data extrapolated from June – August billing records.

Figure 1: Fuel Use



The fuel oil baseline period is partially reconstructed from available billing data for the period June – August 2008 and normalized for average daily usage. Deliveries were on an as-needed basis and the correlation between deliveries and time of use is therefore estimated.

The absolute difference between baseline fuel oil use and post-installation natural gas consumption is approximately 102,000 therms per year or a savings of approximately 73%. The absolute savings do not account for changes in production, which will have a significant influence on fuel or gas use. Because no post-installation data were available for the evaluation the absolute use could not be normalized for production and the savings calculated from a simple bill comparison (subtracting post-install from baseline use) are not reliable and were not used.

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF62
Site Name	MF62
Nexant Project Reviewer	Victor Narkaj
Nexant Project Inspector	Victor Narkaj
Inspection Date and Time	7/31/2008

Measure Description	**Window Replacement**	
	NYSERDA	Nexant
Total Gas Use, MMBtu/y		147
MMBtu/y Savings	0.0	31.3

MMbtu Gas Savings	0.0	31.3
Gross Realization Rate		infinite

Inspection Notes	1. MF16 is 6-story, 10-unit apartment building located in downtown Manhattan originally built in 1890. 2. Each unit has (3) South facing windows (30 total windows on South face) that are the focus of this replacement. The other sides of the buildings are bordered closely by adjacent buildings. Only (4) of the (10) units' windows were replaced (12 total windows replaced). The building owner states that unparticipating tenants declined due to inconvenience of installations. He hopes to convince them to upgrade by next winter and is also considering other measures as well (roof insulation). Nexant will call back in 6 months to check if any other measures are implemented. 3. The TA report states that, "Replacing the original windows will not provide significant energy savings, but will dramatically improve comfort". The yearly gas savings quoted by the TA report is $560/year and the payback for replacement is 53.6years. No itemized MMBTU savings were included in the report, but $560/year savings for 30 windows equates to $224/year savings for the 12 windows replaced. At a cost of $17/MMBtu, the total MMBtu savings for the 12 windows replaced is 13.2MMBtu. 4. The windows to be replaced are original to the building and their dimensions are 8ft by 3ft. They are single pane with wooden frames. The new windows are aluminum, thermally-broken framed with low E coating and double paned. Building owner states that windows were very drafty and created an uncomfortable indoor environment during winter. 5. Two types of savings were considered for this analysis; gas savings due to improved infiltration protection and savings due to the windows themselves. 6. Standard infiltration calculations were used with a measured crack length and ASHRAE estimated leakage. The savings due to the windows was calculated using RESFEN software for one apartment and multiplying that effect across all (4) apartments.

ERS Review Notes	1. The TA study report released on 01/2007 lists four other recommended measures: - turn DHW temperature back to 120-deg F. - install low-flow shower heads and aerators where possible - upgrade hallway lighting to electronic ballast F32-T12 with a daylight sensor on both lights in stairwell skylights. Add motion sensors to control all basement lights - remove existing roof and add 2" rigid XPS foam with gravel ballast (remove cavity vents if possible) ERS made multiple attempts to verify that these measures were not installed, but were not successful in contacting the site.

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF63
Site Name	MF63
Nexant Project Reviewer	Victor Narkaj
Nexant Project Inspector	Victor Narkaj
Inspection Date and Time	8/14/2008

Measure Description	**Weatherseal PTAC's and Weatherstrip Patio Doors**	
	NYSERDA	Nexant
Total Gas Use, MMBtu/y		7,529
Weatherseal PTAC's MMBtu/y Savings	44.0	16.7
Weatherstrip patio doors MMBtu/y Savings	17.0	13.0
MMBtu Savings	61.0	29.8

Gas MMBtu Savings	0.0	29.8
Gross Gas Realization Rate		#DIV/0!

Inspection Notes	1. MF63 is 7-story, 6-unit apartment building located in Manhattan at 8th Ave and 112th St originally built in 2003. There is one 2-bedroom apartment per floor with commercial space on the ground floor. 2. Each apartment has (3) package terminal air conditioning (PTAC) units and (1) patio door that are the focus of this project. The ResTech study suggested weathersealing the PTAC's and weatherstripping the patio doors to reduce infiltration. The PTAC's measure 4ft by 2ft, while the patio doors are 8ft by 6ft (2 doors each 3ft wide). 3. The MMBtu savings in the TA report were calculated using TREAT building modeling software. 4. The onsite inspection yielded visual validation of the weathersealing and weatherstripping. The PTAC units were sealed with a combination caulk and an adhesive foam. The area between the exterior wall and the frame of the PTAC unit appeared fully sealed. The patio doors received a sturdy aluminum weatherstrip along its bottom border with a foam backing and rubber strip. The patio door's vertical borders and top border were also outfitted with adhesive foam insulation strips attached to the frame of the door, creating a nearly air tight seal. 5. Standard infiltration calculations were used with a measured crack length and ASHRAE estimated leakage.

ERS Review Notes	1. NYSERDA total savings adjusted to 0 as per program claimed savings for this project.

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified

Contract ID	MF64
Site Name	MF64
Nexant Project Reviewer	Peter McBride
Nexant Project Inspector	Peter McBride
Inspection Date and Time	4/15/2008

Measure Description	**Pipe Insulation**	
	NYSERDA	Nexant
Total Insulation Length, Feet	213	121
Insulation Thickness, Inches	1 and 2	0.375
Supply Temperature (F)		110
Annual hours of operation		8,760
Heat Loss Reduction, MMBtu/y		24.9
Installed Boiler Efficiency	81.0%	80.0%
MMBtu/y Savings	0.0	31.1

Measure Description	**DHW Temperature Reduction**	
	NYSERDA	Nexant
Summer Gas Use, Therms/day		64.0
DHW/Total Gas Use, %		80%
DHW Gas Use, MMBtu/y		1,869
Baseline Temperature, °F		150
Retrofit Temperature, °F		110
Temperature Reduction, °F		40
Estimated Savings, %		16%
MMBtu/y Savings	0.0	299.0

Measure Description	**Window and Door Replacement**	
	NYSERDA	Nexant
Total Gas Use, MMBtu/y		6,997
DHW Gas Use, MMBtu/y		1,869
Space Heating Gas Use, MMBtu/y		5,129
MMBtu/y Savings	0.0	19.9

MMbtu Gas Savings	0.0	350.1
Gross Realization Rate		infinite

Inspection Notes	1. DHW pipe insulation appeared to be polyethylene foam (similar to PIR type) with no covering, 3/8" thickness. Per maintenance staff, the insulation was installed last winter (07-08). 2. Per maintenance staff, DHW temperature was reduced from 150 to 110°F. 3. Per maintenance staff, approx. 9 windows were replaced (out of approx. 600 in building) and 4 doors were replaced (out of approx. 30 in building). 4. Other gas measures have not been implemented (heating plant upgrade, hot water plant upgrade, and programmable thermostats).
Review Notes	Low % adjusted savings is largely due to partial implementation of measures (of the 7 gas EEMs, only #3, 4, 5, and 10 were partly or fully implemented).

ERS Review Notes	-none

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

MF65

March 22, 2010

SUMMARY INFORMATION

Project ID	MF65
Program Being Evaluated	Multifamily
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Existing building
Customer Business/Product	Apartment building

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	George Sorin Ioan
Report Author	George Sorin Ioan

1. PROJECT SUMMARY

The project consisted of four gas efficiency measures:

1. Install 1600 square feet of blown-in fiberglass (R-19) insulation in the roof cavity.
2. Install thermostatic radiator valves (TRVs) and implement space temperature setback at night.
3. Replace the space heating boiler.
4. Insulate 190 feet of domestic and space heating hot-water pipes.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Roof insulation	Reported			132	
2	TRVs and night setback	Reported			69	
3	Large boiler	Reported			64	
4	Insulate piping	Reported			59	
Total		Reported			324	
		Evaluated			62.6	
		Realization Rate			19.3%	

1.2. Measure Sampling

The billing analysis methodology encompassed the performance of all measures.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	6	$588	
On-site M&V	5	$490	
Analysis	10	$980	**Site Evaluation Cost / Incentive**
Report	4	$392	
Total	25	$2,450	$1,862/$9,250

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID #1: Roof Insulation

The measure consisted of installing 1600 square feet of 6-inch blown-in fiberglass insulation in the roof cavity.

2.1.1. Application Description of Baseline

There was no insulation on the roof cavity.

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.1.2. Evaluation Description of Baseline

There was no insulation on the roof cavity. Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.1.3. Seasonable Variability in Schedule and Production

The space heating system operates only during the heating season. The measure savings vary with the outside temperature.

2.1.4. Application Description of As-Built Equipment and Operation

The roof cavity covers an area of 1600 square feet and was insulated with 6-inch blown-in fiberglass (R-19) insulation.

2.1.5. Applicant Energy Savings Algorithms

The savings have been calculated using TREAT software, which is designed to model the energy use of residential buildings. The project documents do not provide the software input and output files resulting from running the software.

2.1.6. Evaluation Energy Savings Algorithms

This is a verification only evaluation. We were not able to access the roof cavity during the site visit. However, the site contact and the program documents indicate that the roof cavity was insulated as stated in the application. The site contact lives in an apartment located on the top floor, and he indicated that the apartment was warmer since the roof cavity was insulated.

We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data for the twelve months preceding the measure installation and the past year's gas usage.

For baseline and as-built heating systems, we regressed the monthly gas use against the average dry-bulb temperature measured in Central Park, and then we used the regression coefficients to estimate the gas use based on TMY3 dry-bulb temperature for Central Park. We estimated the overall savings resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.1.7. Data Measurement Method

The attic was not accessible and we could not verify the measure installation or measure the temperature in the roof cavity.

2.1.8. Site Sampling Strategy

Sampling was not required for this measure.

2.1.9. Uncertainties

Since we did not have any indication of the temperature values in the cavity before and after the measure was installed, we did not estimate how this measure affected the heating system gas usage.

2.1.10. Non-Energy Impacts

The site contact, who lives on the top floor, indicated that he has felt more comfortable in his apartment since the measure was installed.

2.2. Measure ID #2: TRVs and Night Setback

The measure consisted of installing seven thermostatic radiator valves (TRV) and a central unit that controls the boilers based on the outside temperature and based on programmed schedules.

2.2.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

The energy use assessment report indicates that the space heating was controlled using a heat timer model E, which was programmed to set back temperature during the night. Since the survey for the report was done during the summer, the operation of the controls was not tested. The space heating boilers were not controlled based on outdoor temperature.

2.2.2. Evaluation Description of Baseline

The site contact could not give us details on the pre-retrofit heating control system operation. Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.2.3. Seasonable Variability in Schedule and Production

The space heating system operates only during the heating season. The measure savings vary with the outside temperature.

2.2.4. Application Description of As-Built Equipment and Operation

The application indicates that seven TRVs have been installed in each of the seven apartments in the building. There is no indication of what type of heating controls have been installed.

2.2.5. Applicant Energy Savings Algorithms

The savings have been calculated using the TREAT software, which is designed to model the energy use of residential buildings. The project documents do not provide the software input file and output files resulted from running the software.

2.2.6. Evaluation Energy Savings Algorithms

This is a verification only evaluation. During the site inspection, we verified the TRVs quantity and the heating setback control unit.

The heating control unit is located in the boiler room and operates based on three different parameters: outdoor temperature, space temperature, and scheduling. The heating control unit turns on the boilers if the outdoor temperature is below 50°F and if the space temperature is below the setpoint. The unit is programmed to set back the space temperature during the night. The site contact could not give us additional information on the space temperature setpoints and space temperature setback schedules.

Since the baseline system was equipped with a timer, which was programmed to set back the space temperature, the only impact on the gas use comes from the control unit capability to turn on the boilers based on the outdoor temperature (outdoor temperature reset control).

We did not estimate the gas savings by measure. Instead we performed a billing analysis as described in for first measure.

2.2.7. Data Measurement Method

We verified the TRVs and the space heating control unit installation. The space heating control is programmed to turn on the heat when the outdoor temperature goes below 50°F.

Equipment inspected	TRV	OAT reset and space temperature night setback	
Quantity	7	1	
Measurement equipment	N/A	N/A	
Observation frequency	N/A	N/A	
Metering duration	N/A	N/A	
Accuracy	N/A	N/A	

The photo below shows a screenshot of the MPC Platinum steam cycling heating control.

2.2.8. Site Sampling Strategy

Sampling was not required for this measure.

2.2.9. Uncertainties

The project documents do not indicate the temperature setpoints based on which the gas savings have been estimated. The site contact could not provide us details on the baseline system controls.

2.2.10. Non-Energy Impacts

The automatic controls on the boiler reduce its operating hours and consequently the feedwater used for heating.

2.3. Measure ID #3: Large Boiler

The measure consisted of installing a new Weil-McLain model eighty-space heating steam boiler.

2.3.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	
Replacement of failed equipment	
Replacement of working equipment	X
Industrial process expansion	

The project documents indicate that the old steam boiler was in fair to poor condition. It was capable of dual-fuel operation but the oil delivery system was not operational. The boiler was not equipped with an automatic reset control.

- Boiler Manufacturer: HB Smith
- Boiler Model #: 28-5
- Capacity: 31 boiler hp
- Design supply temperature: 210°F
- Design return temperature: 190°F
- Burner Manufacturer: Power Flame
- Burner Model #: PF C2-GO-15

The following measurements were made with the old boiler at high fire:

Parameter	Measurement
Boiler room temperature	86°F
Gross stack temperature	480°F
Percent O_2	9.1%
PPM CO	3
Smoke number	N/A
Estimated steady-state efficiency	76.6%

2.3.2. Evaluation Description of Baseline

The site contact could not provide us details on the baseline boilers. Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.3.3. Seasonable Variability in Schedule and Production

The space heating system operates only during the heating season. The measure savings vary with the outside temperature.

2.3.4. Application Description of As-Built Equipment and Operation

One Weil-McLain Model 80 boiler has been installed. The boiler has a maximum steam output capacity of 386 MBtuh and is 80% efficient. The boiler is automatically turned on if the outside temperature is below 50^{O}F.

2.3.5. Measure Life

A study of measure life is not included in this evaluation.

2.3.6. Applicant Energy Savings Algorithms

The savings have been calculated using TREAT software, which is designed to model the energy use of residential buildings. The project documents do not provide the software input and output files resulting from running the software.

2.3.7. Evaluation Energy Savings Algorithms

This is a verification only evaluation. During the site visit, we verified that the measure was installed. The boiler is automatically controlled by an MPC Platinum management system. The control unit turns on the boiler when the outdoor temperature is below 50^{O}F. We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data as described above.

2.3.8. Data Measurement Method

We verified the boiler and the heating control unit nameplate, the boiler was not on because the outdoor temperature was above 50°F. We have not been able to measure the boiler combustion efficiency.

We estimated the boiler operating hours by counting the hours during which the outdoor temperature is below 50^{O}F. In our calculations we used TMY3 data from Central Park.

Equipment inspected	Space heating boiler		
Quantity	1		

Boiler efficiency	80%		
Operating hours	3,590 - estimate		
Metering duration	N/A		
Accuracy	N/A		

2.3.9. Site Sampling Strategy

Sampling is not required for this measure.

2.3.10. Uncertainties

The project documents indicate that the baseline space heating boiler had a capacity of 31 hp, which translates into 1,030 MBtuh, while the newly installed space heating boiler has a capacity of 386 MBtuh. There is no indication on what heating capacity the savings have been estimated by the applicant.

The project documents do not indicate the baseline or as-built boiler operating hours, and there is no indication what boiler efficiency was used in the savings calculation. In the savings calculation spreadsheet for the pipes insulation measure, the applicant indicates that the space heating boiler operates 2,920-hr/year. There is some uncertainty in the annual runtime hours of the boiler.

2.3.11. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

2.4. Measure ID #4: Insulate Piping

The measure consisted of insulating 190 feet of DHW and steam pipes in the boiler room and basement.

2.4.1. Application Description of Baseline

There was no insulation on the pipes.

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

2.4.2. Evaluation Description of Baseline

Hot water pipes were not insulated before the measure was installed. Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.4.3. Seasonable Variability in Schedule and Production

The space heating system operates only during the heating season. The measure savings vary with the outside temperatures.

2.4.4. Application Description of As-Built Equipment and Operation

The insulation was installed on domestic hot-water as well as space-heating hot-water pipes. The insulation is 1 inch thick and is made of fiberglass. All the insulated pipes are located in the boiler room and in the basement.

2.4.5. Measure Life

A study of measure life is not included in this evaluation.

2.4.6. Applicant Energy Savings Algorithms

The savings have been calculated by subtracting the heat loss through the insulated pipes from the heat loss through uninsulated pipes. The heat loss has been calculated using the following formula:

Heat loss (Btuh) = [L(ft) x D(ft) x $\Delta t(^{o}F)$ x U(Btu/(h x ft^2 x °F)) x Hours(h)] / Efficiency (%)

Heat loss (Btuh) – annual heat loss through the pipes

L (ft) – pipes equivalent length (includes the actual pipes length, fittings, and valves equivalent length)

D (ft) – pipes external diameter

Δt(°F) – difference between pipe external and internal temperatures

U (Btu/(h x ft^2 x °F)) – pipe conductive heat loss

Efficiency (%) – baseline boiler efficiency – 65% - this value was indicated by the applicant on the savings calculation spreadsheet

Hours (h) – annual DHW and space heating boilers operating hours

2.4.7. Evaluation Energy Savings Algorithms

This is a verification only evaluation. We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data as described above.

2.4.8. Data Measurement Method

The space heating boiler was off during the site visit.

Equipment inspected	Pipe insulation	Domestic hot-water supply pipe	Domestic hot-water return pipe	Space heating steam supply pipe	Space heating steam return pipe	Boiler room
Parameter measured	Thickness	Temperature	Temperature	Temperature	Temperature	Temperature
Measurement equipment	Ruler	Infrared thermometer	Infrared thermometer	Infrared thermometer	Infrared thermometer	Infrared thermometer
Observation frequency	N/A	N/A	N/A	N/A	N/A	N/A
Metering duration	Spot	Spot	Spot	Spot	Spot	Spot
Accuracy	2%	2%	2%	2%	2%	2%

2.4.9. Site Sampling Strategy

Sampling is not required for this measure.

2.4.10. Uncertainties

The savings calculation spreadsheet indicates that the space heating boiler operates 2,920-hrs/yr. In New York City the outside temperature is below 50°F approximately 3,590-hrs/year. We believe the space heating boiler operates at least 3,590-hrs/ year, while the domestic hot water boiler operates throughout the year. There is some uncertainty in the annual runtime hours of the boiler.

2.4.11. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

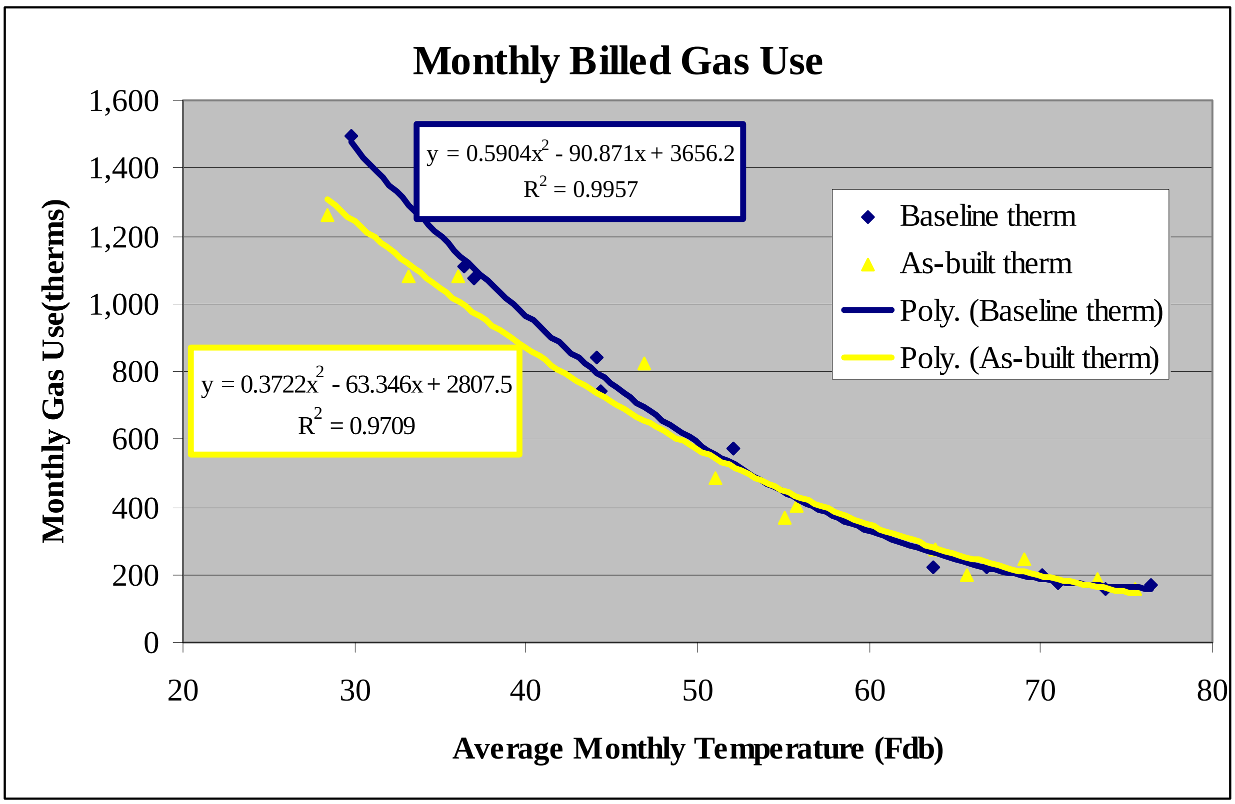
NYSERDA program documents indicate overall savings of 3,240 therms/year. This evaluation estimated 626 therms/year of savings.

A TREAT software model was used to estimate the gas savings resulted from installing the roof insulation, TRVs and heating system control installation, and boiler replacement. Evaluators do not have access to the original TREAT software model. Evaluation site inspection validated equipment installation.

We had access to historical gas bills and we were able compare the pre-retrofit heating system gas use with the as-built heating system gas use. The regression of the heating system gas use versus the outdoor temperature indicates a strong correlation between the heating system gas use and the outdoor temperature in both baseline and as-built systems.

Gas bills issued before the project was implemented, between 1/3/2007 and 1/3/2008, indicate that the heating system gas use was 6,993 therms, while gas bills issued after the project was implemented, between 1/5/2009 and 1/5/2010, indicate that the heating system gas use was 6,561 therms.

The building occupancy remained the same between 2007 and 2010, and we estimated that the internal heating loads remained constant. The evaluation results are illustrated graphically below.



The yellow as-built (post-retrofit) line is lower and shows some savings, particularly in the coldest months, but not close to the levels predicted.

We also speculate that either the baseline conditions were markedly better than modeled—pre-existing insulation level and boiler efficiency—or the TREAT model was not reconciled with bills because the original savings estimates totaled an uncommonly high 60% of baseline space heating energy.

Also, the fact that the building manager reported that the top floor is warmer in the winter indicates that some of the theoretical savings is being lost due to elevated space temperatures in the winter.

3.2. Deviations from Plan

The attic was not accessible for inspection, and we have not been able to visually inspect the measure installation. The site contact and the project documents indicate that the measure was installed as stated in the application.

3.3. Recommendations for Program Designers & Implementers

We would like to have access to the savings estimates algorithms so that we could be able to gather details on the assumptions made by the applicant to develop the system mode.

3.4. Customer Alert

The site contact tried to be helpful but he was not able to provide specific details on the baseline and post-retrofit systems.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	8,033
Building predominant year of construction	1880

3.6. Evaluation Dates

Assignment date	12/21/2009
Plan approval date	1/24/2010
Site visit date(s)	1/25/2010
Draft site report completion date	3/22/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

MF66

5/13/2010

SUMMARY INFORMATION

Project ID	MF66		
Program Being Evaluated	Multifamily		
Customer Name			
Site Name If Different			
Site Address			
Building or Site Type	Multifamily residential		
Customer Business/Product	Apartment building		

Principal Site Contact	Mark Zimet with Dunn Development		
Title			
Phone	718-388-9407	**email**	mzimet@dunndev.com
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Satyen Moray
Plan Author	Satyen Moray

1. PROJECT SUMMARY

This was a new construction project that involved developing fifty-four apartments. This project consisted of several gas efficiency measures:

1) R-39 Roof insulation
2) R-18 Wall insulation
3) Window upgrades, low-e, argon filled aluminum frame windows, U<0.44
4) Higher efficiency boilers for space heating and domestic hot water heating
5) Front-loading Energy Star washing machines
6) Faucet and shower aerators

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Roof insulation	Reported		39	
2	Wall insulation	Reported		24	
3	Window upgrades	Reported		104	
4	Higher efficiency boilers	Reported		166	
5	Front-loading washing machines	Reported		18	
6	Faucet and shower aerators	Reported		29	
Total		Reported		380	$358,344
		Evaluated		817	
		Realization Rate		215%	

1.2. Measure Sampling

The reverse building modeling methodology encompassed the performance of all measures.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	$2,048	
On site M&V	16	$3,023	
Analysis	32	$4,096	**Site Evaluation Cost / Incentive**
Report	12	$1,536	
Total	76	$10,703	3%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID #1: Roof Insulation

This measure consisted of installing 6" polyisocyanurate, R-37 insulation in the roof.

2.1.1. Application Description of Baseline

R-15 insulation.

2.1.2. Evaluation Description of Baseline

Same as the application baseline.

2.1.3. Seasonable Variability in Schedule and Production

The building is occupied year round.

2.1.4. Application Description of As-Built Equipment and Operation

The polyisocyanurate insulation (R-39) covers the entire roof area of 8,547 square feet and parts of the installation were visually inspected by Marc Zuluaga with Steven Winters Associates (SWA) in July 2006.

2.1.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline building with R-15 roof insulation and with R-39 roof insulation in the post case. The analysis was conducted using TMY2 weather file for Central Park, New York.

2.1.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the ESim model with the actual post-case billing data and the corresponding weather data for that period. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. We used March 2008 to March 2009 for the calibration period because we had clean billing data for this period.

We estimated the overall savings that resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.1.7. Data Measurement Method

Prior post installation inspection reports were used to verify the implementation status of this measure.

2.1.8. Site Sampling Strategy

Sampling was not required for this measure.

2.1.9. Uncertainties

We had to rely on the SWA post-installation inspection for the implementation status of this measure as the insulation is now behind walls. If the insulation job was not done correctly, then it is likely that the average R-value of the roof insulation would be less than the documented R-39.

2.1.10. Non-Energy Impacts

There were no non-energy impacts associated with this project.

2.2. Measure ID #2: Wall Insulation

This measure consisted of installing R-13 fiberglass batts and 1″ Roxul mineral wool insulation (R-4.1/inch) between studs and masonry for a total assembly R value of 18.

2.2.1. Application Description of Baseline

R-13 insulation.

2.2.2. Evaluation Description of Baseline

Same as the application baseline.

2.2.3. Seasonable Variability in Schedule and Production

The building is occupied year round.

2.2.4. Application Description of As-Built Equipment and Operation

The R-18 insulation covers a total wall area of 22,115 square feet and parts of the installation were visually inspected by Marc Zuluaga with Steven Winters Associates (SWA) in July 2006.

2.2.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline building with R-13 wall insulation and with R-18 wall insulation in the post case. The analysis was conducted using TMY2 weather file for Central Park, New York.

2.2.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the ESim model with the actual post-case billing data and the corresponding weather data for that period. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. We used March 2008 to March 2009 for the calibration period because we had clean billing data for this period.

We estimated the overall savings resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.2.7. Data Measurement Method

Prior post installation inspection reports were used to verify the implementation status of this measure.

2.2.8. Site Sampling Strategy

Sampling was not required for this measure.

2.2.9. Uncertainties

We had to rely on the SWA post-installation inspection for the implementation status of this measure as the insulation is now behind walls. If the insulation job was not done correctly, then it is likely that the average R-value of the wall insulation would be less than the documented R-18.

2.2.10. Non-Energy Impacts

There were no non-energy impacts associated with this project.

2.3. Measure ID #3: Window upgrades

This measure consisted of installing 154 low-e, argon filled aluminum frame windows rated for a conductivity rating U of less than 0.446 and SHGC of 0.427.

2.3.1. Application Description of Baseline

Wood/vinyl fixed frame with ½-inch double glass, 0.25-inch air space, and tinted windows. We estimated the U-value of the base-case windows to be 0.48 and SHGC of 0.48 using the *Selecting Windows for Energy Efficiency* report as a reference developed by the Lawrence Berkeley National Labs.

2.3.2. Evaluation Description of Baseline

We degraded the U-value suggested above by 10% in our analysis.

2.3.3. Seasonable Variability in Schedule and Production

The building is occupied year round. The roof insulation has a direct correlation with outdoor weather conditions.

2.3.4. Application Description of As-Built Equipment and Operation

The 154 windows are located on all sides of the buildings. A sample of the new frames and windows were visually inspected by Marc Zuluaga with Steven Winters Associates (SWA) in July 2006.

2.3.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline building with wood/vinyl fixed frame with ½-inch double glass, 0.25-inch air space, and tinted windows. The post-case windows were modeled as low-e, argon-filled aluminum frame windows with ¾-inch double glass, 0.5-inch argon space with low-e coating (e=0.1) on surface 2 or 3 and with no tinting. The new windows were modeled with a U value of 0.44 and SHGC of 0.427. The analysis was conducted using TMY2 weather file for Central Park, New York.

2.3.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the ESim model with the actual post-case billing data and the corresponding weather data for that period. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. We used March 2008 to March 2009 for the calibration period because we had clean billing data for this period.

We estimated the overall savings that resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.3.7. Data Measurement Method

Prior post-installation inspection reports were used to verify the implementation status of this measure.

2.3.8. Site Sampling Strategy

Sampling was not required for this measure.

2.3.9. Uncertainties

We had to rely on the SWA post-installation inspection for the implementation status of this measure as the window stickers had been removed. Also, since the new windows have operable frames, it is likely that the building residents open the windows when it gets hot inside their apartments. This issue will be discussed further in this report.

2.3.10. Non-Energy Impacts

There were no non-energy impacts associated with this project.

2.4. Measure ID #4: Higher Efficiency Boilers for Space Heating and Domestic Hot Water Heating

This measure consisted of installing two Lochnivar Powerfin PB1500 boilers (each rated for input of 1.5 MMBtu/hr) rated for 86% efficiency and two Turbomax indirect hot water heaters (RETW 100-9) that support space heating and domestic hot water heating in the facility. The boilers are operated with outdoor air reset controls.

2.4.1. Application Description of Baseline

Space Heating Boiler

The TREAT software modeled the base-case boiler with an efficiency of 75%, outdoor air reset controls, and an outdoor air shutdown temperature of 55ºF. No explanation for the determination of the baseline efficiency was provided in the project documentation.

Domestic Hot Water Boiler

The TREAT software modeled the base hot water heater with an energy factor of 0.72.

2.4.2. Evaluation Description of Baseline

Same as the application baseline.

2.4.3. Seasonable Variability in Schedule and Production

The building is occupied year round. The space heating loads vary with outdoor air conditions and the DHW loads stay consistent throughout the year.

2.4.4. Application Description of As-Built Equipment and Operation

Two Lochinvar Powerfin PB1500 boilers (86% efficient) and two Turbomax indirect hot water heaters have been installed that support the space heating and DHW loads in the facility. (Note that we were unable to test the boiler efficiency due to the property manager’s request to not drill a hole in the exhaust stack.)

Each boiler has a design input capacity of 1.5 MMBtu per hour and output capacity of 1.29 MMBtu per hour and was analyzed for an efficiency of 86%. For the indirect hot water heat portion we used an energy factor of 0.75, which is the same as the TREAT model.

2.4.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential buildings. The TREAT model defined the base-case space heating boiler with an input capacity of 1 MMBtu/hr, an efficiency of 75%, and reset controls. The base-case DHW hot water heater boiler was defined with energy factor of 0.72. The base-case DHW load was estimated at 1,783 gallons per day (using 21 gallons per day per person).

The TREAT software modeled the post-case space heating boiler with an efficiency of 87% and hot water heater with an energy factor of 0.78.

2.4.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the ESim model with the actual post-case billing data and the corresponding weather data for that period. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. We used March 2008 to March 2009 for the calibration period because we had clean billing data for this period.

In the calibrated post-case model we had to increase the DHW load by 13% to match the actual gas billing data.

We estimated the overall savings that resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.4.7. Data Measurement Method

Note that we were unable to test the boiler efficiency due to the property manager's request to not drill a hole in the exhaust stack. So we decided to use nameplate efficiency in our analysis. Visual inspection was used to verify the installation of this measure. The photo below shows an example the boilers installed at the site.

Turbomax Hot Water Heaters

2.4.8. Site Sampling Strategy

Sampling is not required for this measure.

2.4.9. Uncertainties

Since the boiler efficiency was not tested, there is some uncertainty around the efficiency at which the boilers are currently operating.

2.4.10. Non-Energy Impacts

There were no non-energy impacts associated with this project.

2.5. Measure ID #5: Front-Loading Washing Machines

The measure consisted of installing four Energy Star-rated front-loading washing machines in the first floor common laundry room.

2.5.1. Application Description of Baseline

The TREAT software model used top-loading washing machines with hot-cold water cycles that use 9,956 kWh per year per unit and 19,594 gallons of hot water per year per unit.

2.5.2. Evaluation Description of Baseline

Same as the application baseline.

2.5.3. Seasonable Variability in Schedule and Production

The washing load is unlikely to vary with seasons.

2.5.4. Application Description of As-Built Equipment and Operation

Four new Maytag Neptune front-loading washing machines were installed.

2.5.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline top-loading washers with 9,956 kWh per year per unit electric use and 19,594 gallons of hot water use per year per unit. The post-case front-loading washers were modeled with 1,792 kWh per year per unit electric use and 11,043 gallons of hot water use per year per unit.

2.5.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the DHW used in the ESim model with the actual post-case billing data and the corresponding weather data for that period. In the calibrated post-case model we had to increase the DHW load by 13% to match with the actual gas billing data. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. We used March 2008 to March 2009 for the calibration period because we had clean billing data for this period. Note that in the ESim model the DHW load represents measures 5 and 6 combined.

We estimated the overall savings that resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.5.7. Data Measurement Method

Visual inspection was used to verify the installation of this measure.

2.5.8. Site Sampling Strategy

Sampling is not required for this measure.

2.5.9. Uncertainties

The hours the front-loading washing machines get used is the biggest uncertainty variable for this measure and is largely controlled by the number of residents in the building and the charge levied by the management for the use of these machines.

2.5.10. Non-Energy Impacts

This measure involved the installation of four Energy Star-rated front-loading clothes washer over the federal-standard counterpart of equivalent size. Energy Star-rated models require less water per cubic foot per cycle than standard models; this leads to savings in heating energy, water, and water-discharge costs. For example, an Energy Star-rated washer consumes 7.5 gallons per cycle per cubic foot, whereas the federal standard consumes 9.5 gallons per cycle per cubic foot. [1] A table of results is presented below.

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[1] Primary and secondary research sources:

a) Primary references: *Clothes Washers Key Product Criteria,* Energy Star, http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

b) Secondary references: *Energy Star Savings Calculator: Clothes Washer*, Energy Star, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls

Table of Results
(The washer models installed at this site fall under the 2 cubic foot category.)

Capacity	Standard Water Usage	Energy Star-Rated Usage	Water Savings	Cost Savings	Normalized Savings	Qty	Water Savings	Cost Savings
cu ft	gal/cycle	gal/cycle	gal/cycle	$/year	$/cf/yr	#	gal/yr	$/yr
2	19	15	4	$9.40	$4.7	4	4,160	$38

Assumed:	9.5	gal/cf/cycle, standard
	7.5	gal/cf/cycle, Energy Star
	$0.009037	per gallon for water and sewer in bronx
	260	cycles per year

2.6. Measure ID #6: Faucet Aerators

This measure consisted of installing a 1.5 gpm low-flow faucet aerators in half of the apartments. The low-flow showerheads did not get installed.

2.6.1. Application Description of Baseline

The TREAT base-case model used 2.2 gpm aerators on half the units.

2.6.2. Evaluation Description of Baseline

Same as the application baseline.

2.6.3. Seasonable Variability in Schedule and Production

The DHW consumption is unlikely to vary with seasons.

2.6.4. Application Description of As-Built Equipment and Operation

Two randomly selected apartments were inspected during the site visit. One apartment had the 1.5 gpm faucet aerator while the other did not.

2.6.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the base-case water load at 1,791 gallons per day while the post-case water load due to the low-flow faucet aerators was estimated at 1,680 gallons per day.

2.6.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a whole building HVAC analysis using the ESim building energy modeling software (developed by Dr. Kelly Kissock at the University of

Dayton). We tried to get access to a trial edition of the multifamily version of the TREAT software but failed to get any response from the software developers.

We calibrated the DHW used in the ESim model with the actual post-case billing data and the corresponding weather data for that period. In the calibrated post-case model we had to increase the DHW load by 13% to match with the actual gas billing data. The post-case and base-case building energy use was then normalized based on TMY3 weather data for Central Park in Manhattan. Note that in the ESim model the DHW load represents measures 5 and 6 combined.

We estimated the overall savings that resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.6.7. Data Measurement Method

Visual inspection was used to verify the installation of this measure.

2.6.8. Site Sampling Strategy

Sampling is not required for this measure.

2.6.9. Uncertainties

Resident behavior with regard to the use of the faucets is the single largest uncertainty variable for this measure.

2.6.10. Non-Energy Impacts

This measure involved installing faucet aerators in half of the fifty-four apartments. Aerators limit the flow of water through kitchen and bathroom faucets, thereby saving heating energy and water consumption. The baseline for this measure is a faucet head without an aerator that consumes no more than 2.2 gpm, as mandated by federal regulations[2]. The savings results are presented below.

Annual Usage	Standard		Energy Star		Savings	# of	Total Water Savings	Cost Savings
Hours	gpm/unit	gal/year/unit	gpm/unit	gal/year/unit	gal/year/unit	Apts	gals/yr	$/yr
18	2.2	2,376	1.5	1,620	756	54	20,412	$184

[2] Primary and secondary research sources

Primary references: *Reduce Hot Water Use for Energy Savings,* U.S. Department of Energy, http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13050

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

NYSERDA program documents indicate overall savings of 3,500 therms per year (350 MMBtu/yr) which includes a penalty for installing high efficiency lighting and refrigerators. Since this was a gas evaluation project, we did not include the negative impact of the lighting and refrigerators in our reporting; consequently we used gas savings of 3,800 therms per year (380 MMBtu/yr). This evaluation estimated savings of 8,174 therms per year (817 MMBtu/yr).

A TREAT software model was used to estimate the gas savings that resulted from installing the six measures – roof insulation, wall insulation, window upgrades, higher efficiency boilers, front-loading washers, and faucet aerators. Evaluation site inspection validated installation of some of these measures.

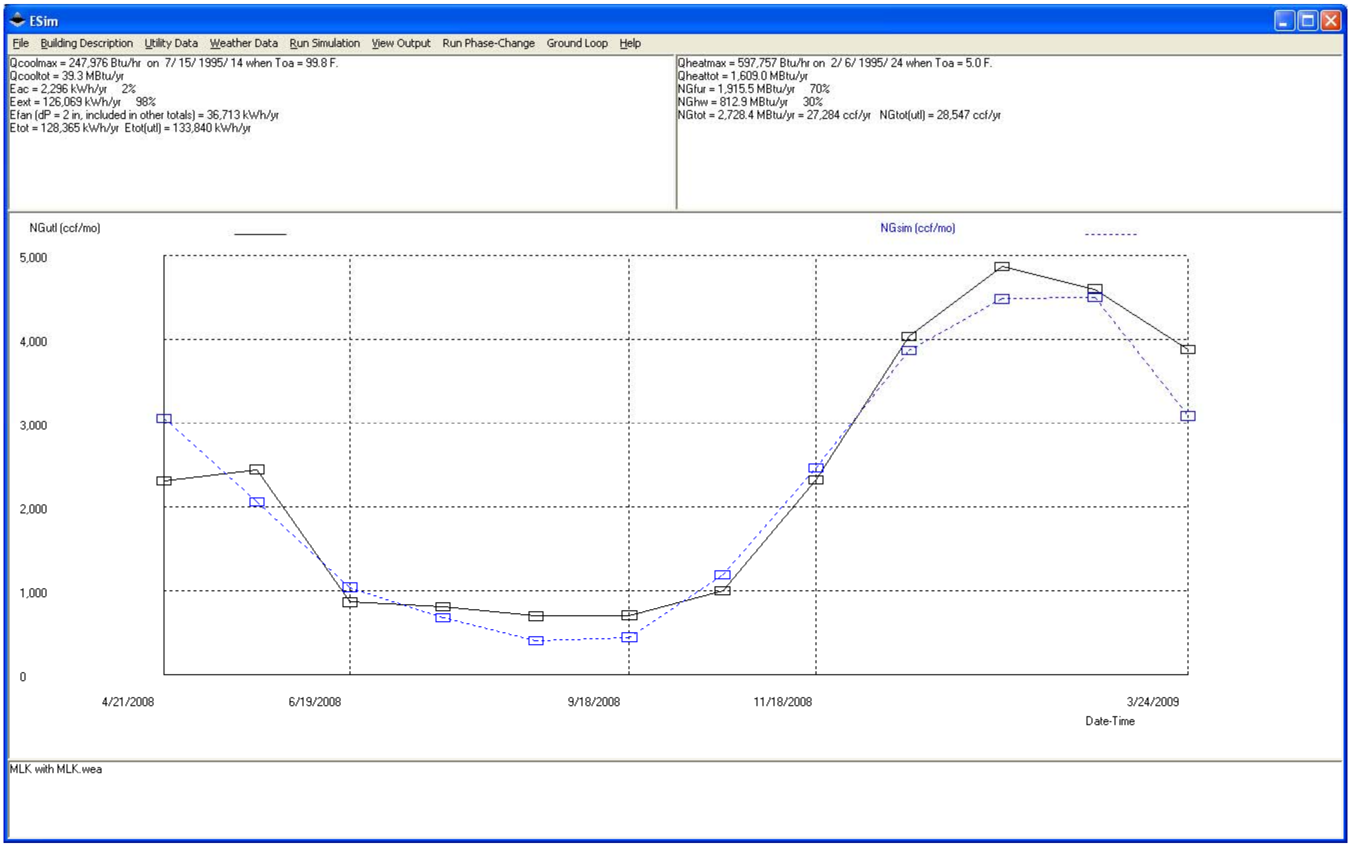
We had access to historical gas and electric billing data for this site from the time of its occupancy representing the post-case scenario. The TREAT model had predicted post-case gas use of 13,113 therms per year and electric use of 209,691 kWh per year while the average annual gas use for the site over the past 3 years has been over 28,000 therms per year and electric use is around 127,000 kWh per year. Therefore, the actual gas use at this site is off from the TREAT models under predicted use by over 200% and electric use is -165%.

This data indicated a significant mismatch between the TREAT model and actual billing data for this site. Since we verified most of the measures and SWA staff had visually inspected the installation of the insulation, this discrepancy led us to conclude that the resident behavior is largely responsible for this difference.

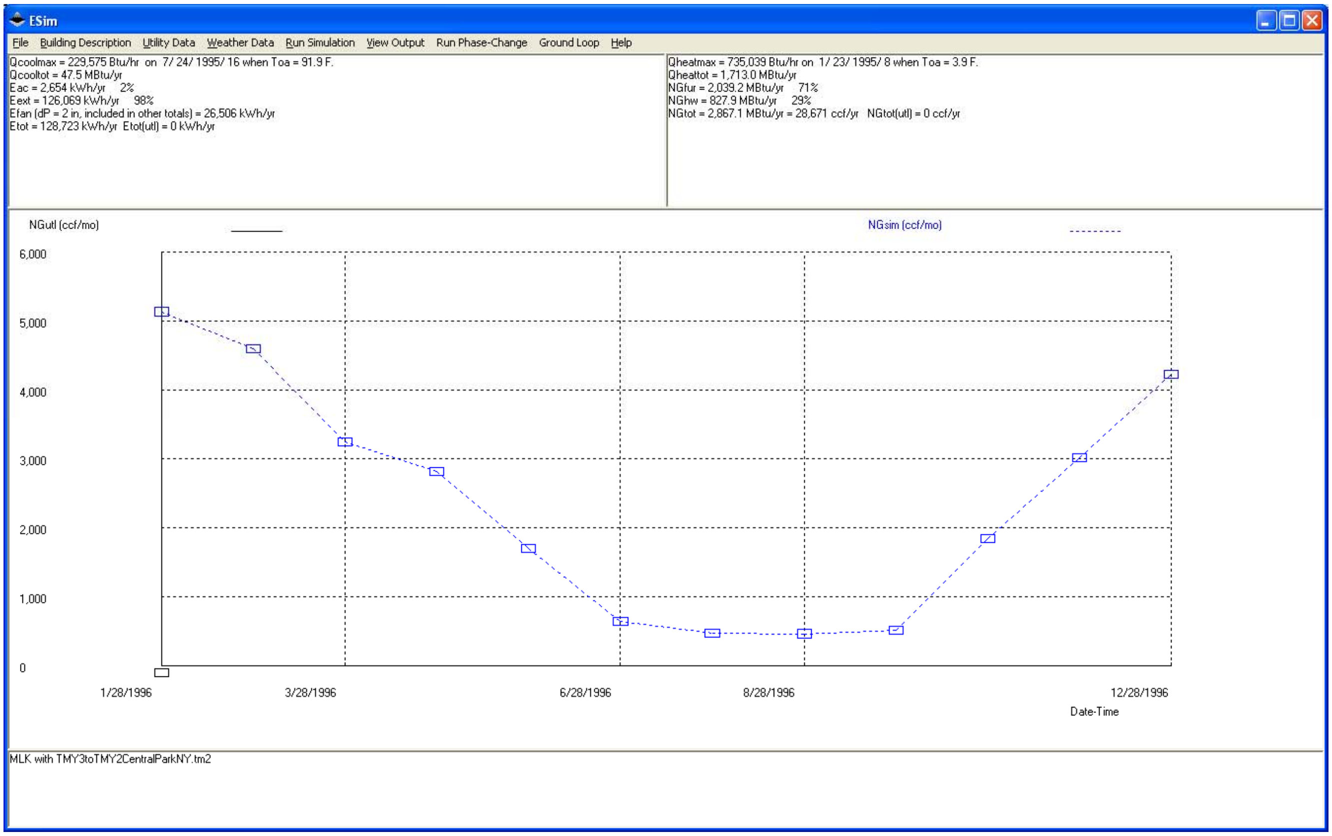
As we mentioned earlier, since we did not have access to the TREAT software, we chose to use ESim software (developed by Dr Kelly Kissock at the University of Dayton). ESim is a building energy simulation tool that combines powerful computational capabilities and graphics in an easy-to-understand user interface. ESim offers a feature to calibrate building models to measured energy consumption and was the major reason for us selecting the software for this analysis. It is appropriate for passive-solar, simple single-zone and large multi-zone buildings with sophisticated HVAC systems and controls.

We used the billing history data for March 2008 to March 2009 for the calibration exercise. We used the above described post-case building parameters to develop the model. The plot below shows the results of the calibration exercise. The blue-dotted line represents the ESim model predicted gas use while the black solid line represents the actual billed gas data.

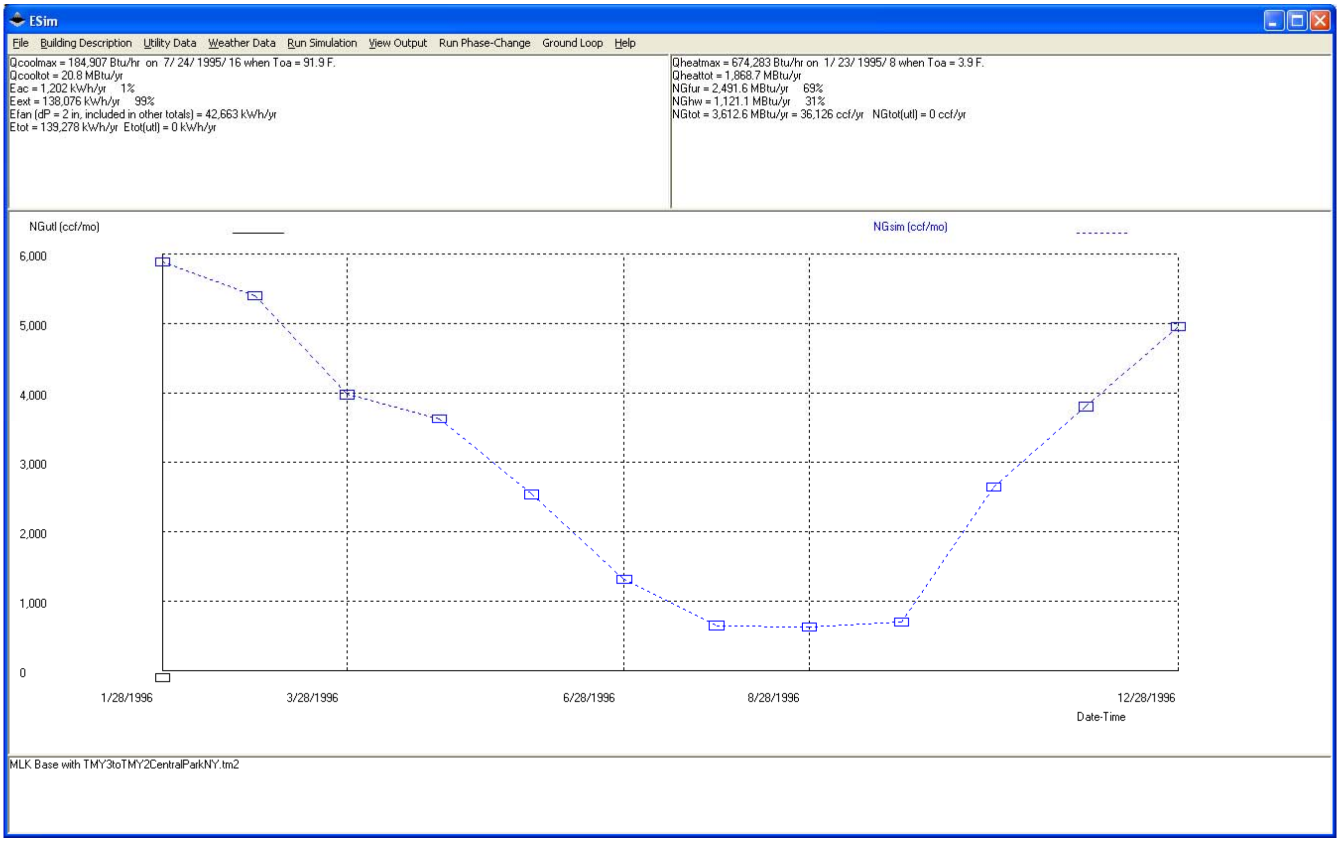
The initial simulation model showed considerably less energy use than billed. To reconcile, evaluators increased the infiltration/fresh air rate from the 0.1 air changes per hour used by TREAT up to 0.85. We also had to elevate the temperature setpoints from 68ºF to 75ºF. The calibrated model was then adjusted for the base-case parameters discussed in this report keeping all other variables constant including the ACH and setpoints.



The following screen shot shows the post case building natural gas use with the TMY3 weather file for Central Park, NY.



The next plot shows the base-case building natural-gas use plot with TMY3 weather file for Central Park, NY.



The table below summarizes the results of the ESim modeling exercise.

	Total Natural Gas Use (therms/yr)
Billed data (March 2008-March 200()	28,548
ESim calibrated post-case model output	28,084
ESim TMY3 post-case model output	29,531
ESim TMY3 base-case model output	37,705
Savings	**8,174**
Reported savings	**3,800**
Realization rate	**215%**

Several factors contribute to the large variance in the estimated savings by the evaluators:

1) We had to use a different building energy modeling software to reassess the savings for this project as we did not get access to the TREAT software. It is likely that TREAT and ESim have minor variances in their algorithms that can introduce discrepancies between the results. Also TREAT used TMY2 weather data, whereas the evaluation ESim model used TMY3 data.
2) In order to get a close match to the post-case billing data, we had to increase the building infiltration rate to 0.85 ACH. This would seem to indicate that the apartment doors or windows are left open more than planned during the winter months. This could potentially be a result of tightening the building envelope. In order to conduct a fair comparison between the base-case and post-case building operations, we used the same 0.85 ACH for the base case model as well. The inflated load increases savings associated with the space heating boilers.
3) The measure savings breakdown also shows indirect heating penalty estimated in the TREAT model as a result of installing energy efficient lighting and refrigerators. If the post-case lighting kW and its associated on-hours are significantly different than that predicted in the TREAT model then it is likely to have an indirect impact on the overall gas savings. We did not verify the lighting and the refrigerators inside the building; however they were verified by the SWA staff during their inspection visits.
4) In the ESim model we modeled the heating space temperature to 75ºF during the winter months with no setback. The apartment temperatures will vary based on the resident behavior and it is very likely that the temperatures are kept high and constant all the times. The TREAT model had occupied and unoccupied heating space temperature setpoints of 68ºF and 66ºF respectively with an 18-hour-per-day unoccupied period. Since this is a low-income residential apartment building with limited control capability, we anticipate that the residents set higher temperatures than indicated in the TREAT model and that the temperatures do not get set back at all. This change increases the temperature difference across the surfaces in the winter, increasing the envelope measure savings correspondingly and also increasing the boiler savings.
5) We could not verify the post-case boiler efficiency. The TREAT model predicted savings based on installing an 87% efficient boiler while the nameplate suggested that the boiler can at best be 86% efficient. It is likely that the post-case boilers operate at less than 86% efficiency.

3.2. Deviations from Plan

We had planned on initially using billing analysis to validate the savings for the measures at this site. However, after inquiring with the NYSERDA program staff we found that this was a NCP project with no pre-retrofit billing history.

Therefore, we decided to move on with using the TREAT model and calibrating it for the actual billing data. Since we did not get access to a trial version of the TREAT software we had to recreate a generic model of this site in ESim that was calibrated with the post-case billing data.

3.3. Recommendations for Program Designers & Implementers

We would like to recommend informing property managers/owners to install efficiency testing ports on boiler exhausts. The post-case billing data indicated a significantly different building usage pattern than what had been predicted in the TREAT model. We recommend reviewing large NCP projects after completion for their match with the predicted energy use and working with the sites that exhibit a significant deviation from the predicted usage.

3.4. Customer Alert

None.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	52,096
Building predominant year of construction	2006

3.6. Evaluation Dates

Assignment date	1/21/2009
Plan approval date	2/24/2010
Site visit date(s)	2/9/2010, 3/10/2010
Draft site report completion date	4/27/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF67
Site Name	MF67
Project Close Date	
NYSERDA Program Component	Res Tech/Assisted Multifamily Program
Nexant Project Reviewer	Yujie Cui
Nexant Project Inspector	Peter McBride
Inspection Date and Time	9/2/2008

Measure #1 Description	**Replace the current boiler control system with EnerGuard control and install 5 indoor space temperature sensors**	
	NYSERDA	**Nexant**
Annual Gas Consumption 4/2/02-4/1/03 (MMBtu)		1,014
Annual Boiler Gas Consumption (MMBtu) (estimated at 70% of annual consumption)		710
HDDs between 4/1/02-3/31/03		5,116
Normalized HDDs (Year 1961-1990) @ 65F Base		4,957
(MMBtu)		688
Annual Savings (MMBtu)	160	103

Measure #2 Description	**Install low flow showerheads and aerators**	
	NYSERDA	**Nexant**
Quantity of Showerheads	1	18
Showerhead Baseline Flow rate (gpm)	2.5	
Showerhead Post-installation Flow rate (gpm)	1.5	2.0
Thermal Savings/showerhead (MMBtu)	4.9	2.280
Annual Savings for Showerheads (MMBtu)	4.9	41
Quantity of Sink Faucet Aerators	N/A	20
Faucet Baseline Flow rate (gpm)	N/A	4
Faucet Post-installation Flow rate (gpm)	N/A	2.2
Annual Savings for Sink Faucet (MMBtu)	N/A	16
Total Measure Savings (MMBtu)	44	57

Measure #3 Description	**Install weather stripping and door sweeps on exterior doors**	
	NYSERDA	**Nexant**
Quantity of Exterior Doors	1	4
Annual Savings (MMBtu)	21	24

Measure #4 Description	**Disconnect the central exhaust fan and install a switch-activated exhaust fan in each**	
	NYSERDA	**Nexant**
Quantity of Bathrooms	18	18
Central Fan Operating Hours Per Day (hrs)	24	24
(hrs)		2
Small Fan Air Flow (cfm)		22
Total Ventilation (cfm)	1,000	396
Boiler Efficiency	70%	70%
Baseline Energy Consumption (MMBtu)		72.7
Post-installation Energy Consumption (MMBtu)		6.1
Annual Savings (MMBtu)	186	67

MMbtu Gas Savings	411	251
Gross Realization Rate		0.61

Inspection Notes	1. Per the facility, the construction was completed on 12/12/2007. 2. The above four measures installation was verified and the following information was collected: *Measure 1* : The new EnerGuard controller has replaced the old Tekmar control and five indoor space sensors were installed as part of the new system. *Measure 2:* There are total 18 showerheads, one per unit, and 20 bath sink faucets. *Measure 3:* There were 4 exterior doors installed with weather-stripping. *Measure 4:* There was a total of 18 units and bathrooms in this facility. *Measure 5:* This measure was implemented but not reported to NYSERDA. 3. The facility provided a copy of Energy Use Assessment submitted to NYSERDA dated 6/24/2003
Review Notes	Nexant's analysis assumptions or calculation methodologies are listed below: *Measure 1:* assumptions: (1) Boiler (space heating) gas usage account for 70% of annual gas consumption. (2) Measure savings is based on normalized HDDs at the 65F base. *Measure 2:* Nexant used the Gas DSD data and corrected the DSD by actual showerhead gpm for shower head replacement. Faucet aerator thermal savings is fundamentally calculated by the following equations: Annual therms baseline = baseline annual water Gals x 8.31 lb/gal x 1.0 Btu/lb.F x (Temp_out - Temp_in)/Heater Efficiency Annual therms post = post annual water Gals x 8.31 lb/gal x 1.0 Btu/lb.F x (Temp_out - Temp_in)/Heater Efficiency Annual therms savings = Annual therms baseline - Annual therms post *Measure 3:* Nexant used the DSD data. *Measure 4: calculation methodology:* Baseline MMBtu = total exhaust airflow (cfm) x 1.08 (Btu/cfm.F.hrs) x HDDs (F.Days) x 24 (hrs/day) / 1000,000 (Btu/MMBtu) Post-installation MMBtu = post-installation hrs per day / baseline hrs per day MMBtu Savings = Baseline MMBtu - Post-installation MMBtu *Measure 5: calculation methodology:* Annual Savings = Gas DSD savings x length adjustment x temp adjustment x dia adjustment Length Adjustment =Nexant Length/DSD length Temp Adjustment = (Nexant temp - space temp)/(DSD temp - space temp) Dia Adjustment = Nexant dia ^2 / DSD dia^2

ERS Notes	1. The report released on 02/2008 lists another recommended measure: - Remove Baseboards in Living Units 2. The report does not show any pipe insulation measure 3. NYSERDA program documents show a claimed savings of 411 MMBtu for this project. This is the savings against which the evaluated savings have been compared.

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF68
Site Name	MF68
NYSERDA Program Component	Assisted Multifamily Program
Site Contact	
Site Address	
Nexant Project Reviewer	Nisa Foster
Nexant Project Inspector	Peter McBride
Inspection Date and Time	12/17/2008

	NYSERDA	Nexant
Measure Description	**Heating System Replacement - Boiler**	
Boiler Manufacturer	-	Lochinvar Power -Fin
Boiler Model	-	PBW0751-F13
Boiler Input Capacity, kBtu/hr	-	500
Boiler Output, kBtu/hr	-	425
Boiler Quantity	1	1
Boiler Fuel	Natural Gas	Natural Gas
Hot Water End Use	Space Heating	Space Heating
Energy Savings MMBtu	109	-
Measure Description	**EMS**	
Model	-	Energuard
Manufacturer	-	Pepco Energy Products
Energy Savings MMBtu	183	-
Measure Description	**DHW System Upgrade - DHW heater replacement**	
Boiler Manufacturer	-	Lochinvar
Boiler Model	-	EWN250PM
Boiler Input Capacity, kBtu/hr	-	250
Boiler Quantity	1	1
Boiler Fuel	Natural Gas	Natural Gas
Hot Water End Use	DHW	DHW
Energy Savings MMBtu	57	-
Measure Description	**Water Measure - Showerheads and Faucet Aerators**	
Quantity	16 Showerheads and 18 Aerators	16 Showerheads and 18 Aerators
gpm	2	2
Energy Savings MMBtu	86	-
Measure Description	**Stack Effect (Infiltration reduction) - Door sweeps**	
Quantity	-	5
Energy Savings MMBtu	204	-
Baseline MMBtu Consumption	-	15930
Retrofit MMBtu Consumption	-	13759

Gas MMBtu Savings	655	217
Gross Gas Realization Rate	-	33%
Inspection Notes	Equipment found is reflected in the table above. Also, new insulation was found in the boiler room - this measure is not in the report.	
Review Notes	1. Gas usage obtained from the gas bills (July 2006 through June 2007) was used to calculate gas usage before the measures were implemented. Winter savings is calculated using the data from October 2006 to May 2007. 2. Gas usage obtained from the gas bills from October 2007 to September 2008 was used to calculate gas usage after the measures were implemented. Winter savings is calculated using the data from October 2007 to May 2008 3. The installation date of boilers is 9/7/07. It was assumed that the other measures were installed near this date. 4. Actual therms between July and June 2006-2007 were adjusted by monthly HDDs for comparison with 2007-2008 data.	

ERS Review Notes	1. Total project claimed savings adjusted to be consistent with program claimed values.

NEXANT EQUIPMENT INFORMATION TABLE - 2008 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF69		
Site Name	MF69		
NYSERDA Program Component	Assisted Multifamily Program		
Site Contact			
Site Address			
Nexant Project Reviewer	Nisa Foster		
Nexant Project Inspector	Salil Gogte		
Inspection Date and Time	December-08		
	NYSERDA	**Nexant**	**ERS**
Measure Description	**Heating Plant Replacement - Boilers**		
Boiler Manufacturer		Patterson-Kelley	Patterson-Kelley
Boiler Model		NM 1500	NM 1500
Boiler Input Rating, MBtu/hr		1,500	1,500
Boiler Output Rating, MBtu/hr		1,275	1,275
Boiler Quantity		2	2
Boiler Fuel		Natural Gas	Natural Gas
Efficiency		0.85	0.85
Baseline MMBtu Consumption		7,908	4,274
Retrofit MMBtu Consumption		3,721	3,721
MMBtu Savings	629	4,186	553
Measure Description	**Intall Low Flow Showerheads**		
Showerhead Quantity	42	unable to verify	unable to verify
Showerhead Flow Rate, gpm	not available	unable to verify	unable to verify
MMBtu Savings	106	106	106
MMbtu Gas Savings	735	4,292	659
Gross Realization Rate		584%	90%
Inspection and Review Notes:	1. Annual Gas Usage used for calculations was obtained from the gas billing data for the 2008. 2. Billing data for the old boilers was not obtainable. Engineering calculations were preformed to estimate the gas consumption of the old boilers using the assumption that the amount of heating the building requires is the same before and after the boilers were changed. The efficiency of the old boilers was assumed to be 80%. The new boilers have a rated efficiency of 85%. 3. Nexant was unable to verify the installation of the low flow showerheads. Showerheads rated at 2.5 gpm were seen on site. Nexant randomly inspected about 6 apartments (other apartments were occupied and inaccesible) and the showerheads installed were the old Niagara brand 2.5 gpm each. Showerheads were not retrofitted in these apartments. On-site personnel were unable to verify installation of showerheads. The super indicated that all ECMs were implemeted before his recruitment. The site has 102 1-3 bedroom apartments. Due to lack of accurate information, savings are calculated assumming 42 showerhead installations per EME report. 4. On site personnel were not familiar with boiler installation specifics. Per Nexant's judgement and discussions with the management firm the analysis is based on four modular boilers replaced with 2 condensing boilers, with lower heating capacity of each boiler. The site likely had 5 total boilers, however, 1 boiler was not not functional.		
ERS Review Notes	ERS evaluators estimated the pre-retrofit heating system gas usage based on the post-retrofit heating system gas usage. The post-retrofit system is 11% more efficient than the pre-retrofit system, as stated in program documents. ERS's impacts are smaller than the savings estimated by NEXANT because we do not make any assumtions on the pre-retrofit units output. Nexant estimates that the each pre-retofit system unit had the same output as the post-retrofit units system. Since the pre-retrofit system is equipped with 4 units, while the post-retrofit system is equipped with 2 units, it looks like the heating capacity of the post-retrofit system is 50% of the heating capacity of the pre-retrofit system.		

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF70
Site Name	MF70
NYSERDA Program Component	PAHP
Nexant Project Reviewer	Yujie Cui, Peter McBride
Nexant Project Inspector	Salil Gogte, Peter McBride
Inspection Date and Time	10/10/08, 6/18/09

Measure Description 1#	**Replace Window A/C Sleeves**	
	NYSERDA	**Nexant**
Quantity of Window A/Cs		642
Average winter wind velocity (fpm)		895
Annual savings (MMBtu/y)	785.0	1,242.2

Measure #2 Description	**Install low-flow showerheads**	
	Gas DSD	**Nexant**
Quantity of Showerheads	1	310
Showerhead Baseline Flow rate (gpm)	2.5	N/A
Showerhead Post-installation Flow rate (gpm)	1.5	2.5
Thermal Savings/showerhead (MMBtu/y)	4.9	0.0
Annual Savings for Showerheads (MMBtu/y)	4.9	0.0

Measure #3 Description	**Install DHW circulation controls**	
	Gas DSD	**Nexant**
Quantity	1	5
Thermal Savings/unit (MMBtu/y)	32.9	32.9
Annual Savings (MMBtu/y)	32.9	164.5

Measure #4 Description	**Install Barometric and Automatic Dampers in Elevator Machine Rooms**	
	NYSERDA	**Nexant**
Annual Savings (MMBtu/y)	90.9	0.0

MMbtu Gas Savings	0	1,407
Gross Realization Rate	infinite	

Inspection Notes	1. Four gas efficiency measures were partially or fully implemented, as listed above.
Review Notes	1. The facility boiler efficiency was assumed based on the age of boilers. 2. The space condition (70F/30%) was assumed to be constant. 3. The exhaust fan airflow was assumed to be 25 cfm for continuous operation based on ASHRAE standard 62.1-2004. 4. The low-flow showerhead measure listed in the Gas DSD is assumes a retrofit of 2.5 GPM to 1.5 GPM showerheads. Since the current showerheads are 2.5 GPM, and the baseline GPM is unknown, Nexant finds no savings for this measure. 5. The savings for the DHW circulation controls was calculated using the Gas DSD adjusted for actual on-site conditions. 6. The second inspection showed that the installation of the barometric dampers was not completed, so Nexant finds no savings for this measure. The original plan was to install automatic actuators connected to smoke detectors, this was not completed. The dampers

ERS Review Notes	1. Individual measure savings are pulled from project report, but are not claimed by the program. The program claimed 0 Mmbtu of gas savings for this project. The total NYSERDA Mmbtu Gas Savings reflects this.

Site-Specific Measurement and Verification Report

MF71

5/13/2010

Summary Information

Project ID	MF71
Program Being Evaluated	Multifamily
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Multifamily residential
Customer Business/Product	Apartment building

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone		**email**	
Third Party Contact			
Title			
Company			
Phone		**email**	

Lead Evaluation Engineer	Satyen Moray
Plan Author	Satyen Moray

1. PROJECT SUMMARY

This project was major renovation on a 167-apartment, multi-story facility that had the following gas efficiency measures:

1) Weather stripping all exterior doors and all balcony doors
2) Night setback
3) Four condensing boilers for space heating and domestic hot water heating
4) Front-loading washing machines (ten)

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Gas Savings (MMBtu/yr)	Incentive Value ($)
1	Weather stripping	Reported		46	
2	Night setback	Reported		305	
3	Condensing boiler	Reported		4,716	
4	Front-loading washing machines	Reported		157	
Total		Reported		5,224	$151,272
		Evaluated		4,069	
		Realization Rate		78%	

1.2. Measure Sampling

The billing analysis methodology encompassed the performance of all measures.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	$2,048	
On site M&V	16	$3,023	
Analysis	32	$4,096	**Site Evaluation Cost / Incentive**
Report	12	$1,536	
Total	76	$10,703	7%

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID #1: Weather Stripping

The measure consisted of installing weather stripping on all exterior doors and balcony doors in the apartments.

2.1.1. Application Description of Baseline

There was no weather stripping.

2.1.2. Evaluation Description of Baseline

There was no weather stripping on the exterior doors and balcony doors. Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.1.3. Seasonable Variability in Schedule and Production

The weather stripping will reduce or eliminate draft losses and has a significant correlation with outdoor weather conditions.

2.1.4. Application Description of As-Built Equipment and Operation

The weather stripping covers four exterior doors and the balcony doors in the 167 apartment units.

2.1.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline buildings with different leakage areas – building #3 with 16.1 square inches, building #2 with 129 square inches, building #1 with 48.3 square inches, and a zero leakage area in the post case. The net result was to capture the delta infiltration between the base-case and the post-case building operations because even with the weather stripping, infiltration would not be fully avoided.

2.1.6. Evaluation Energy Savings Algorithms

This is a basic evaluation. We inspected the weather stripping on a sample of doors and found the weather stripping to be intact.

We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data for the 12 months before and after the measure installation.

For baseline and as-built heating systems, we regressed the monthly gas use against the monthly sum of heating degree days (HDD) measured in Central Park for the billing periods and then we used the regression coefficients to estimate the gas use based on TMY3 HDD for Central Park. We estimated the overall savings resulted from implementing the project by subtracting the as-built system gas use from the baseline system gas use.

2.1.7. Data Measurement Method

Visual inspection was used to verify the installation of this measure on a sample of the apartments. The photo below shows an example of weather stripping installed on a door at this site.

2.1.8. Site Sampling Strategy

Sampling was not required for this measure.

2.1.9. Uncertainties

Since we do not have any indication of the infiltration rates before and after the measure was installed, we did not estimate how this measure affected the heating system gas usage.

2.1.10. Non-Energy Impacts

There was no non-energy impacts associated with this measure.

2.2. Measure ID #2: Night Setback

This measure was not implemented. This measure required the installation of programmable thermostats in the 167 apartments and was contingent upon installing submeters in the apartments. Since the submetering project was not implemented, the programmable thermostat project also got dropped.

2.2.1. Application Description of Baseline

The TREAT software model described the heating baseline space temperature setpoint to be 74ºF during the occupied period and 72ºF during the unoccupied period with an unoccupied time of 8 hours per day.

2.2.2. Evaluation Description of Baseline

None as this measure was not implemented.

2.2.3. Seasonable Variability in Schedule and Production

Not applicable.

2.2.4. Application Description of As-Built Equipment and Operation

The programmable thermostats were not installed. The apartment units mostly have manual thermostats for controls.

2.2.5. Applicant Energy Savings Algorithms

The savings for this measure were calculated using the TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT model defined a schedule in which the occupied space temperature was 74ºF and the unoccupied temperature was 70ºF during the heating season. The model predicted 8 unoccupied hours per day.

2.2.6. Evaluation Energy Savings Algorithms

Not applicable.

2.2.7. Data Measurement Method

Not applicable.

2.2.8. Site Sampling Strategy

Not applicable.

2.2.9. Uncertainties

We could not verify the night setback aspect of the boiler controller.

2.2.10. Non-Energy Impacts

There were no non-energy impacts associated with this measure.

2.3. Measure ID #3: Condensing Boilers

This measure consisted of installing four Aerco Benchmark 2.0 condensing boilers that support space heating and domestic hot water heating in the facility. The new boilers are also operated with outdoor air reset controls.

2.3.1. Application Description of Baseline

Space Heating Boiler

The project documents indicate that the space heating hot water boiler's exterior was in fair to good condition. It was capable of dual-fuel operation but the boiler had not burned oil for several years before replacement. The boiler was not equipped with an automatic reset control.

Boiler manufacturer: Pacific

Boiler model #: 6082

Capacity: 150 hp

Design supply temperature: 180ºF

Design return temperature: 160ºF

Burner manufacturer: Gordon-Piatt

Burner model #: FL12.9G030

Since the boiler was not operational during the summer, the engineers were not able to test the boiler for its operating efficiency. The efficiency was however estimated using the following:

Measurement	Boiler
Boiler room temperature	95ºF
Gross stack temperature	505ºF
Percent O_2	6.5%
PPM CO	50
Smoke number	N/A
Estimated steady-state efficiency	78%

Domestic Hot Water Boiler

The project documents indicate that the domestic hot water (DHW) was generated by a separate boiler serving two 1,800-gallon storage tanks. A thermostatic mixing valve was connected to tankless coils in the space heating boilers as a backup. The steady state efficiency of the boiler was measured as:

Measurement	Boiler
Boiler room temperature	94ºF
Gross stack temperature	430ºF
Percent O_2	10.1%

PPM CO	24
Smoke number	N/A
Estimated steady-state efficiency	78%
Estimated AFUE	69%

2.3.2. Evaluation Description of Baseline

Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.3.3. Seasonable Variability in Schedule and Production

The domestic hot water loads are anticipated to be weather independent while the space heating loads are dependent on outdoor conditions.

2.3.4. Application Description of As-Built Equipment and Operation

Four Aerco Benchmark-2.0 condensing boilers have been installed that support the space heating and DHW loads in the facility. (Note that less than one year after the installation of the condensing boilers, a 75-kW CHP system was installed at the site that reduced the DHW loads on the condensing boilers significantly). Each boiler has a design input capacity of 2 MMBtu per hour and output capacity of 1.706 MMBtu per hour and were analyzed for an efficiency of 90%. The boilers are automatically turned off if the outside temperature is above 70^{O}F and operate with an outdoor reset. The boilers feature 20:1 turndown ratio.

2.3.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential buildings. The TREAT model defined the base-case space heating boiler with an input capacity of 13.98 MMBtuh and an annual efficiency of 71% and with no reset controls. The base-case DHW boiler was defined with an input capacity of 1.24 MMBtuh with design supply water temperature of 145ºF and a thermal efficiency if 78% (energy factor of 0.65). The base-case DHW system had 24/7 recirculation and DHW load was estimated at 7,204 gallons per day.

The TREAT software modeled the post-case boiler with input capacity of 13.98 MMBtuh and 90% annual efficiency. The hot water temperature would float between 130ºF and 180ºF depending on outdoor air temperature. The post-case DHW was analyzed using the above mentioned condensing boiler specifications (90% thermal efficiency) with the added energy factor of 0.85 during the heating and non-heating season.

2.3.6. Evaluation Energy Savings Algorithms

During the site visit, we verified that the measure has been installed. The boilers are centrally controlled and operate in parallel. We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data as described above. The photo below shows the boilers.

2.3.7. Data Measurement Method

We verified the boiler and the heating control unit nameplate. We took spot combustion efficiency reading for one of the three boilers and also deployed loggers to monitor the boiler performance over a period of several weeks as a part of the condensing boiler evaluation. The customer reported control settings reset according to the following schedule: 0ºF outside air temperature (OAT) – 162ºF supply water temperature (SWT) and 50ºF OAT SWT of 122ºF. We spot-measured the following:

Measurement	Boiler
Boiler room temperature	80ºF
Gross stack temperature	323ºF
Percent O_2	7.1%
PPM CO	2
Smoke number	N/A
Outside air temperature	48ºF
Return water temperature	121ºF
Estimated steady-state efficiency	82.9%

2.3.8. Site Sampling Strategy

Sampling is not required for this measure.

2.3.9. Uncertainties

There is uncertainty in the resident behavior (space temperature setpoints and hot water use) that has a direct impact on the load on the boilers.

2.3.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure. However, there is likelihood that condensing boilers require slightly higher maintenance and consequently insurance premiums compared to the standard boilers. We do not have quantifiable information to estimate this impact at this time.

2.4. Measure ID #4: Front-Loading Washing Machines

The measure consisted of installing ten Energy Star-rated front-loading washing machines.

2.4.1. Application Description of Baseline

Top-loading washing machines.

2.4.2. Evaluation Description of Baseline

The TREAT software model used top-loading washing machines with hot-cold water cycles that use 585 kWh per year and 26,955 gallons of hot water per year.

Since we performed a billing analysis to estimate the gas savings, the baseline for the entire project was the pre-retrofit heating system gas usage normalized based on TMY3 weather data for Central Park in Manhattan.

2.4.3. Seasonable Variability in Schedule and Production

The washing load is unlikely to vary with seasons.

2.4.4. Application Description of As-Built Equipment and Operation

Ten new front-loading washing machines were installed in building #2.

2.4.5. Applicant Energy Savings Algorithms

The savings were calculated using TREAT software, which is designed to model the energy use of residential and multifamily buildings. The TREAT software modeled the baseline top-loading washers with 585 kWh per year per unit electric use and 26,955 gallons of hot water use per year per unit. The post-case front-loading washers were modeled with 585 kWh per year per unit electric use and 13,478 gallons of hot water use per year per unit.

2.4.6. Evaluation Energy Savings Algorithms

We did not estimate the gas savings by measure. Instead we performed a billing analysis using the gas usage billing data as described above.

2.4.7. Data Measurement Method

Visual inspection was used to verify the installation of this measure. The photo below shows an example of a front-loading washing machine installed at the site.

2.4.8. Site Sampling Strategy

Sampling is not required for this measure.

2.4.9. Uncertainties

The amount of time the front-loading washing machines get used is the biggest uncertainty variable for this measure and is largely controlled by the number of residents in the building and the charge levied by the management for the use of these machines.

2.4.10. Non-Energy Impacts

This measure involved the installation of ten Energy Star-rated front-loading clothes washer over federal-standard counterpart of equivalent size. Energy Star-rated models require less water per cubic foot per cycle than standard models; this leads to savings in heating energy, water, and water-discharge costs. For example, an Energy Star-rated washer consumes 7.5 gallons per cycle per cubic foot, whereas the federal standard[1] consumes 9.5 gallons per cycle per cubic foot.

Table of Results
(The washer models installed at this site fall under the 2-cubic foot category)

Capacity	Standard Water Usage	Energy Star-Rated Usage	Water Savings	Cost Savings	Normalized Savings	Qty	Water Savings	Cost Savings
cu ft	gal/cycle	gal/cycle	gal/cycle	$/year	$/cf/yr	#	gal/yr	$/yr
2	19	15	4	$9.40	$4.7	10	10,400	$94

Assumed:	9.5	gal/cf/cycle, standard
	7.5	gal/cf/cycle, Energy Star
	$0.009037	per gallon for water and sewer in bronx
	260	cycles per year

[1] Primary and secondary research sources:

Primary references: *Clothes Washers Key Product Criteria*, Energy Star, http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

Secondary references: *Energy Star Savings Calculator: Clothes Washer*, Energy Star, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerClothesWasher.xls

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

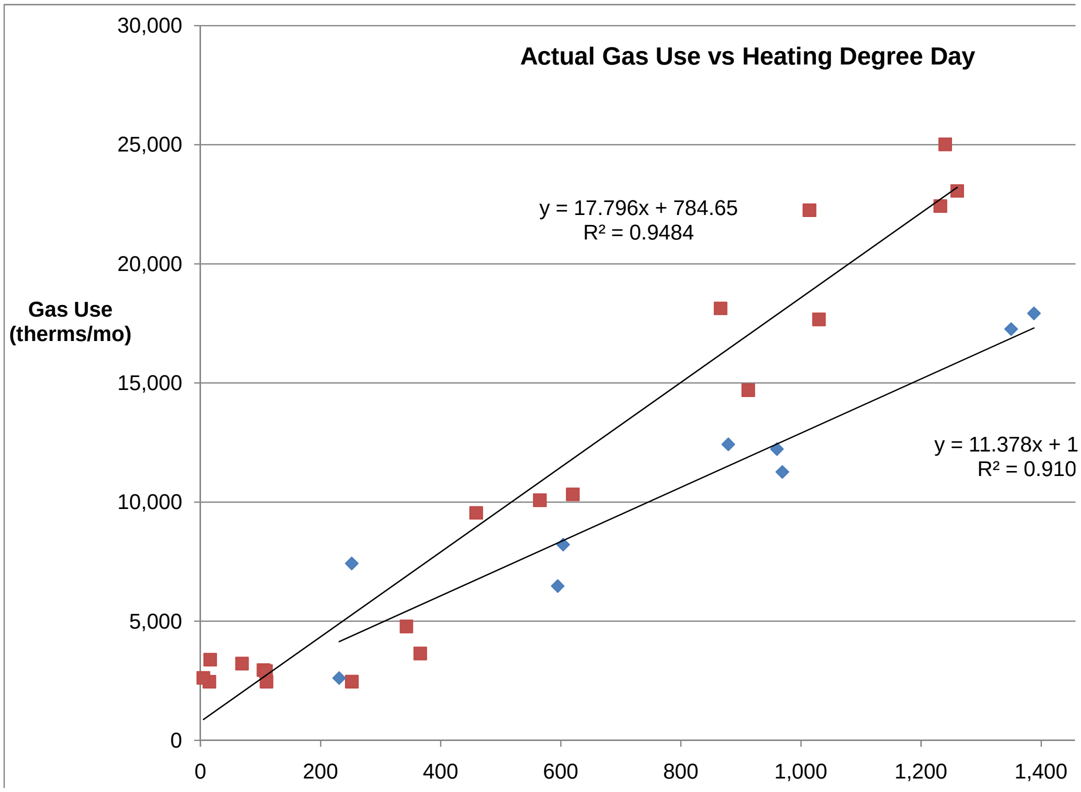
NYSERDA program documents indicate overall savings of 51,460 therms per year. This evaluation estimated 40,692 therms per year of savings.

A TREAT software model was used to estimate the gas savings that resulted from installing the four measures – weather stripping, night setback, condensing boilers, and front-loading washers. Evaluation site inspection validated equipment installation.

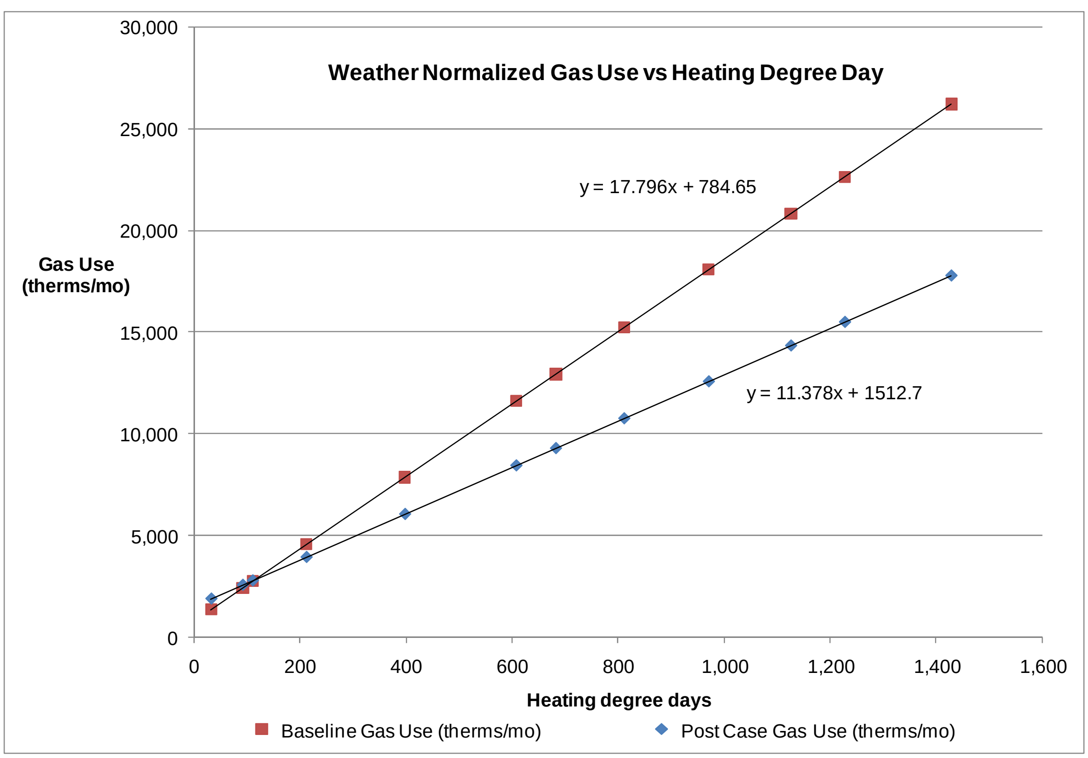
We had access to historical gas bills, and we were able compare the pre-retrofit heating system gas use with the as-built heating system gas use. The regression of the heating system gas use versus the outdoor temperature indicates a strong correlation between the heating system gas use and the outdoor temperature in both baseline and as-built systems.

We were provided with natural gas bills before the project was implemented (between 10/6/2005 and 10/5/2006) and for part of the year after the project was implemented (between 11/3/2006 and 9/6/2007). Note that within 12 months after the installation of the new condensing boilers (from 11/5/2007), a new 75-kW CHP system was installed at this site that significantly reduced the DHW loads. The CHP project was not within the scope of this project and thus was not evaluated. Review of the post CHP / boiler gas bills indicate that the entire DHW load is now supported by the cogen system at all times. The gas bills for the base-case boiler indicate that the DHW loads represented an annual gas consumption of 26,000 therms per year. Using the base-case efficiency of 78% and the tested boiler efficiency of 82.9%, the elimination of DHW loads on the condensing boiler has reduced the annual savings projected for the condensing boilers by about 1,300 therms per year.

The building occupancy remained the same between the base-case and post-case periods mentioned above. The plot below shows the facility gas use plotted versus the corresponding heating degree day for the base-case and post-case periods. The linear regression lines with R-squares exceeding 0.9 indicates a high correlation between weather and gas use at this site.



The following plot shows the weather normalized (TMY3 data) base-case and post-case gas use for this project vs HDD.



The post-case line shows a clear separation from the base-case gas use and the gap widens as the weather gets colder.

Several factors contribute to the reduced savings estimated by the evaluators:

1) The night setback measure did not get implemented; hence the overall savings potential was reduced as a result of that measure not getting implemented.
2) The measure savings breakdown also shows indirect heating penalty estimated in the TREAT model as a result of installing energy efficient lighting. If the post-case lighting kW and its associated on-hours are significantly different than that predicted in the TREAT model then it is likely to have an indirect impact on the overall gas savings. We did not verify the lighting inside the buildings or their operating hours.
3) The other variable affecting the post-case gas use is the behavior of the residents in the building as the units are supplied hot water for space heating at all times when outdoor air temperature is below 70ºF. Since there is no submetering, the residents do not have any motivation to cut back their energy use.
4) The base-case boiler efficiency was “estimated” and not measured as the boiler was not running during the summer months. The base-case boiler was therefore estimated to operate at 71% while it is possible that the base-case boiler operated with better than the efficiency estimated in the project documentation.
5) The post-case or new condensing boilers were modeled in the TREAT software to operate at a steady 90% efficiency. Our March spot combustion tests yield an efficiency of only 83% and the boilers were clearly not condensing, as their exhaust temperatures were in excess of 200ºF. Based on our short-term monitoring of the boiler and its performance, we are fairly certain that the new boilers do not condense (even with outdoor air reset controls), which is resulting in reduced savings.
6) The TREAT software model predicted savings using TMY2 weather data for New York while the evaluators used TMY3 weather data for the same location. TMY3 weather data typically indicates that the average temperatures are warmer than those used in the TMY2 models; therefore, it is likely that the gas use for space heating predicted using TMY3 data will be less than that predicted using TMY2 data.

3.2. Deviations from Plan

None.

3.3. Recommendations for Program Designers & Implementers

We would like to recommend better post-installation verification protocols as only documentation connected with the inspection of the new condensing boilers was provided. The TA study analyzed various measures at this site and project documents did not clearly describe which of the recommended actions were actually implemented at the site.

3.4. Customer Alert

None.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	179,800
Building predominant year of construction	2006 (Upgraded)

3.6. Evaluation Dates

Assignment date	12/21/2009
Plan approval date	2/24/2010
Site visit date(s)	3/11/2010, 3/25/2010
Draft site report completion date	4/23/2010

3.7. Checklist

Report submission package includes:

- ☑ This report
- ☑ All analysis spreadsheets or model input files

NEXANT EQUIPMENT INFORMATION TABLE - 2007 GAS EVALUATION

ERS Verified - 5/2010

Contract ID	MF72
Site Name	MF72
Project Close Date	April, 2006
NYSERDA Program Component	Res Tech
Nexant Project Reviewer	Yujie Cui
Nexant Project Inspector	Salil Gogte
Inspection Date and Time	4/17/2008

Measure Description 1A#	**Install an indirect fired doemstic hot water system (tanks)**	
	NYSERDA	**Nexant**
Quantity of Tanks		3
Heater GPM		8.0
Temperature rise (126F-60F)		66.0
Annual hrs		2,500
Annual DHW consumption (MMBtu)		1,979
Baseline system thermal efficiency		0.77
Retrofit system thermal efficiency		0.82
Annual savings (MMBtu)	222.6	156.7

Measure Description 1B#	**Install insulation for the DHW tanks**	
	Gas DSD	**Nexant**
Quantity of Tanks		3
Size of Tank/each (gal) (20-60 in DSD)	40	79.2
Size of Tank/each (KBtuh)	75.0	
Tank surface ratio estimation (1.0 for DSD)	1.0	1.3
Thermal efficiency	0.76	0.82
Annual Hrs	2,500	2,500
Annual savings/tank (MMBtu)	12.34	15
Total savings (MMBtu)	37	46

Measure Description 2#	**Install Boiler Control - Improve temperature Control**	
	Gas DSD	**Nexant**
Heating Degree Days (HDDs)	4,910	0
Thermal efficiency	0.7	0.77
Annual energy input for heating (MMBtu)	4,102	4,052
Annual savings (MMBtu)	401	363

Measure Description 3#	**Cover window A/C in the winter**	
	NYSERDA	**Nexant**
Quantity of Window A/Cs		30
Average winter wind velocity (fpm)		895
Annual savings (MMBtu/yr)	182	91

Inspection Notes	1. Heating system is baseboard fin-tube heaters, and is enabled when the outdoor air temerature is lower than 55F. The system is enabled 24/7. 2. Per the facility, the boiler supply water temperature set point was 180F. It is now reset based on OA temp. 3. The boiler temperature was 136F during Nexant's inspection. 4. Domestic water set point was 126F. 5. Facility implemented five of the eight measures recommended in the study: New Domestic Hot Water (1A, 1B), Improve Boiler Control (2) and Cover Window A/Cs (3) were analyzed for gas impacts. Upgrade lighting (4) and Close Unused gas account (5) were implemented but do not have associated gas impacts. 6. Facility plans to implement the pipe insulation and thermostat control measures in the near future. Nexant will contact the facility at the end of the year to investigate.
Review Notes	1. Baseline boiler efficiency was based on reported boiler combustion efficiency and estimated boiler and piping system loss. 2. Energy savings for measure 1# (installing an indirect fired domestic hot water system) was estimated based on a 5% thermal efficiency improvement. 3. NYSERDA savings for measure 2# and 3# were assumed to be based on the Gas DSD data since measure 2# savings were not reported by NYSERDA and measure 3# were only part of one measure in NYSERDA's report. Nexant savings for measures 2# and #3 were based on the Gas DSD values adjusted based on actual operationing conditions.
NYSERDA Reported MMBtu Savings	0
Nexant Verified MMBtu Savings	0
Realization Rate	infinite
Non-Gas Impacts: Oil (MMBtu)	657

ERS Review Notes	1) There is no gas use at this facility. Fuel oil is used to fire all boilers.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

NC35

March 23, 2010

SUMMARY INFORMATION

Project ID	NC35
Program Being Evaluated	NCP
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	Food Distribution Center
Customer Business/Product	Refrigerated Warehouse

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	George Sorin IOAN
Report Author	George Sorin IOAN

1. PROJECT SUMMARY

The project was implemented at a new construction facility consisting of 157,000 ft^2 of refrigerated warehouse and 26,000 ft^2 of office and supporting spaces. The project consisted of installing ten energy efficiency measures that impact the electric energy and gas use:

1. High efficiency rooftop VAV units w/ evaporative cooling
2. Demand control ventilation in office areas
3. Free cooling (economizers)
4. Variable speed drives on air handling units
5. High speed loading dock doors with energy efficient insulated loading dock doors
6. High efficiency lighting fixtures with motion sensors
7. Insulation upgrades on roof and envelope
8. High efficiency split refrigeration units with evaporative coolers
9. Energy efficient charges for lift trucks with time clock
10. Building management system

The applicant reported that 1,777 therms have been saved by implementing the measures. Based on conversations with facility staff, only energy efficiency measures (EEMs) 1, 2, and 7 impact the facility's gas use.

1.1. Savings

The *ex ante* project savings have been calculated using a whole building simulation approach. The building simulation was created using Trace 700 v6.1.2. There is no indication on how each installed measure impacts the gas use, only a total gas impact for the project.

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMBtu/yr)	Incentive Value ($)
Total	Measures #1, #2, and #7	Reported			177.7	
		Evaluated	2,557		121.6	
		Realization Rate			68.4%	

1.2. Measure Sampling

The project documents do not indicate what measures have an impact on the gas use. The site contact informed us that only the measures installed in the office space have an impact on the gas use. We will evaluate all measures installed in the office area.

1.3. Budget

Task	**Hours**	**Cost Including Expenses**	
M&V plan	6	$588	
On-site M&V	11	$1,078	
Analysis	20	$1,960	**Site Evaluation Cost / Incentive**
Report	10	$980	
Total	66	$6,488	$6,488/$428,105

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure #1: High Efficiency Rooftop Units for Office Areas

The project application does not provide details on each installed measure. It only provides a list of proposed energy efficiency measures. However, the site contact provided us with a document that gives high level details on the measures installed. This document indicates that eleven Carrier 48PG rooftop units (RTUs) with gas-fired furnace efficiencies ranging from 81% to 82% have been installed in the office space.

During the site visit we collected nameplate data for all units that serve the office space. The table below shows the RTUs list and their capacity.

Model Number	Quantity	Input (Btu/hr)	Output (Btu/hr)	Thermal Efficiency (%)
48PGEM05-J-60-S4	2	75,000	60,800	81%
48PGEM07-J-60-S4	1	113,000	91,500	81%
48PGEM08-J-60-S4	1	181,000	148,400	82%
48PGEM12-J-60-S4	5	226,000	185,300	82%
48PGEM24-M-60-S4	2	365,000	295,650	81%

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

The project documents indicate that the base case design was considered the New York State Energy Conservation Construction Code (NYSECCC). The exact date of permit filing is not known, but the 2002 and 2007 NY ECCC minimum efficiency standards are the same for this measure: 80% thermal efficiency and, for units less than 225,000 Btu/h, 78% AFUE.

2.1.2. Evaluation Description of Baseline

The evaluation baseline will be according to both the 2002 and 2007 New York State Energy Conservation Construction Code. The baseline furnace efficiencies for the RTUs are outlined in the table below.

TABLE 803.2.2(4)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d,e]	TEST PROCEDURE[a]
Warm air furnaces, gas fired	< 225,000 Btu/h	—	78% AFUE or 80% E^c_t	DOE 10 CFR Part 430 or ANSI Z21.47
	≥ 225,000 Btu/h	Maximum capacity[c]	80% E^f_t	ANSI Z21.47
Warm air furnaces, oil fired	< 225,000 Btu/h	—	78% AFUE or 80% E^c_t	DOE 10 CFR Part 430 or UL 727
	≥ 225,000 Btu/h	Maximum capacity[b]	81% E^g_t	UL 727
Warm air duct furnaces ,gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.9
Warm air unit heaters, gas fired	All capacities	Maximum capacity[b]	80% E_c	ANSI Z83.8
Warm air unit heaters, oil fired	All capacities	Maximum capacity[b]	80% E_c	UL 731

For SI: I British thermal unit per hour = 0.2931 W.

a. Chapter 10 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Minimum and maximum ratings as provided for and allowed by the unit's controls.
c. Combination units not covered by the National Appliance Energy Conservation Act of 1987 (NAECA) (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) shall comply with either rating.
d. E_t = Thermal efficiency. See test procedure for detailed discussion.
e. E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
f. E_c = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
g. E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

2.1.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.1.4. Application Description of As-Built Equipment and Operation

The as-built equipment consisted of the installation of eleven rooftop units (RTUs) with gas-fired furnace efficiencies ranging from 81% to 82% in the office space. No details have been provided on the operation and type of the installed equipment.

2.1.5. Applicant Energy Savings Algorithms

The savings have been calculated using TRACE 700 v6.1.2. Simulation input files were not made available for this project.

2.1.6. Evaluation Energy Savings Algorithms

This is a “basic” grade evaluation project; predicted gas savings are worth about $2,000 per year. We collected data on actual equipment and load and setpoint schedules on-site and performed monthly and annual bin-based analysis, modeling the as-built conditions reconciled with provided gas bills. Then we removed the three measures from the model to estimate baseline energy use, subtracting one from the other to compute savings. Because there was no measure-level *ex ante* savings estimates, the evaluation did not separate savings either.

We also estimated the electric energy savings associated with the three installed measures.

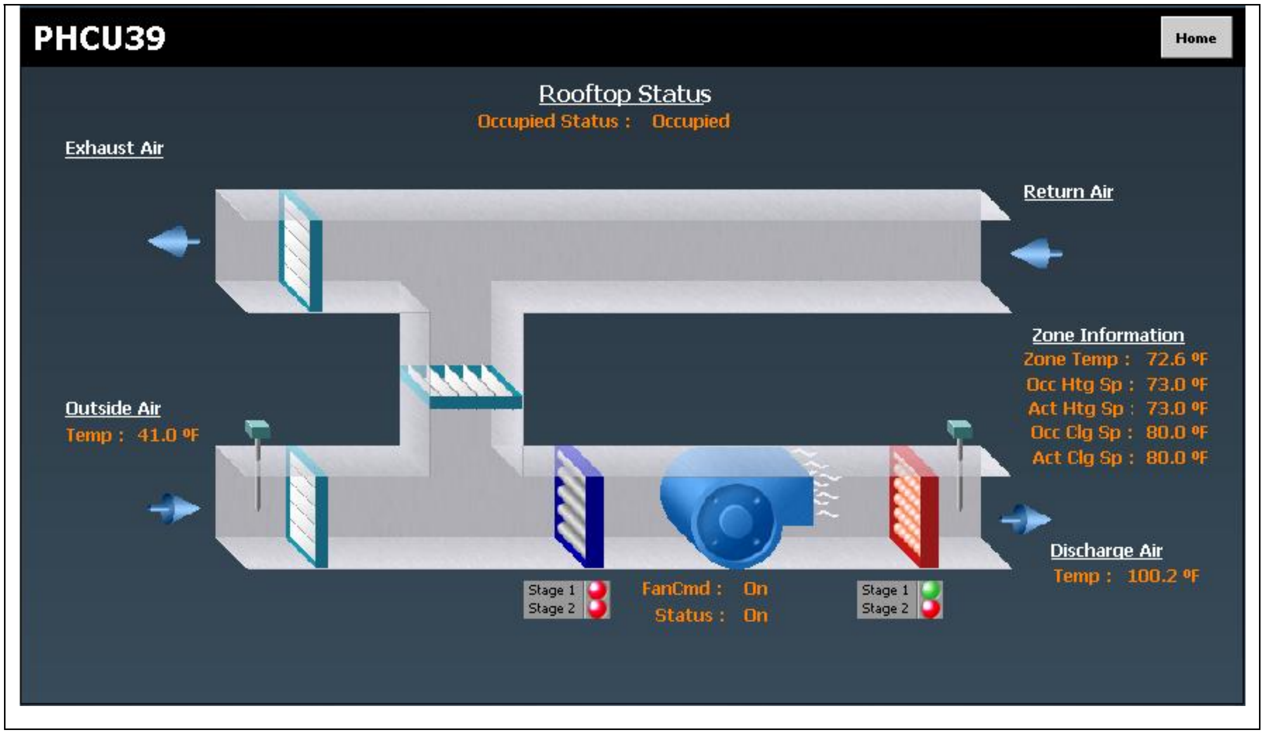
2.1.7. Data Measurement Method

During the site visit, we collected nameplate data for all eleven RTUs and took screenshots from the EMS system showing the operation schedules of two RTUs in typical spaces in the office area. Although the outdoor temperature was 41°F, some spaces did not call for heating. The site contact indicated that the RTUs that serve the office space are on occupied mode from 7 AM to 11 PM, Monday to Friday, and that the space temperature setpoints range from 71°F to 73°F.

The site contact indicated that approximately forty persons occupy the office space during the regular office hours. The office space has only three outdoor walls: the glazed area on the North wall is approximately 20% of the wall surface, the glazed area on the East and West walls is approximately 5% of the wall surfaces, and the South wall is directly connected to the warehouse.

2.1.8. Site Sampling Strategy

We gathered data on all eleven RTUs that serve the office space. The photo below shows what the status of one RTU was at the time of our visit.



2.1.9. Uncertainties

Uncertainties are expected to arise due to differences in the manufacturer specified RTU efficiency and the actual operational efficiency of the units. Additional uncertainties are expected to be associated with the equipment operating hours.

2.1.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

2.2. Measure #2: Demand Control Ventilation for Office Areas

The project application does not provide details on each installed measure. It only provides a list of proposed energy efficiency measures. The project documents indicate that the sensors that measure the CO_2 level in the space are installed as an option on RTUs. The site contact provided us with a document that gives high level details on the measures installed. This document indicates that ten of the eleven rooftop units (RTUs) that serve the offices are equipped with demand ventilation (DCV) controls.

2.2.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

The project documents indicate that the base case design was considered the New York State Energy Conservation Construction Code. The document provided by the site contact indicates that the baseline equipment for this measure is a system with no DCV controls. There are no other details on the baseline system.

2.2.2. Evaluation Description of Baseline

Table 6-1 of ASHRAE 62.1-2007 states that for an office space the minimum outdoor air must be 5-cfm/person plus 0.06-cfm/ft^2, while the default value for occupant density is five persons/1000ft^2.

2.2.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.2.4. Application Description of As-Built Equipment and Operation

The project documents indicate that the CO_2 sensors are installed as on option on RTUs. The documents provided by the site contact indicate that the as-built equipment consisted of installing ten RTUs equipped with DCV controls. All the units serve the offices.

2.2.5. Applicant Energy Savings Algorithms

The savings have been calculated using TRACE 700 v6.1.2. Simulation input files were not made available for this project.

2.2.6. Evaluation Energy Savings Algorithms

This is a basic evaluation-only project. As indicated on section 2.1.7 above, we collected data needed to create a model of the office space area so that we can estimate the gas savings associated with the installation of the DCV controls on the ten RTUs. The site contact could not verify that the DCV controls had been installed. The CO_2 sensors are installed as on option on the RTUs. The site contact indicated that there are forty occupants in the office area during the regular office hours. In the analysis we estimated that thirty occupants are in the space at any given time during the office hours.

We estimated that the outdoor air requirements for the baseline are:

Occ hrs: 5 cfm/person X 5 persons/1,000-ft^2 X 26,000 ft^2 + 0.06-cfm/ ft2 X 26,000-ft^2 =-2,210 cfm

Unocc hrs: 2,210 cfm

We estimated that the outdoor air requirements for the as-built are:

Occ hrs: 5 cfm/person X 30 persons = 150 cfm

Unocc hrs: 0 cfm

This change in outside air was incorporated into the evaluation building simulation model.

2.2.7. Data Measurement Method

The site contact could not provide any information on the DCV operation and was not aware of what DCV does. Evaluators did not identify the sensors during the site visit and presumed the system was installed. Since the program documents indicate that the DCV controls have been installed, we estimated the measure impact on the gas usage.

2.2.8. Site Sampling Strategy

Sampling strategy was not necessary for this measure.

2.2.9. Uncertainties

There is uncertainty associated with the estimated operating hours of the RTUs and the occupancy of the space varies during the day, which results in uncertainty in the evaluated measure impact for this measure.

2.2.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

2.3. Measure #7: Building Envelope Upgrades

The project application does not provide details on each installed measure. It only provides a list of proposed energy efficiency measures. However, the site contact provided us with a document that gives high level details on the measures installed. This document indicates that this measure consisted of installing wall and ceiling insulation with high R-values.

2.3.1. Application Description of Baseline

The measure is reported as (*choose one with an "X")*:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

The project documents indicate that the base case design was considered the New York State Energy Conservation Construction Code. The document provided by the site contact indicates that the baseline equipment for this measure consisted of the following:

- R-13 wall assembly
- R-25 wall assembly separating office space and the refrigerated warehouse
- R-15 roof assembly

2.3.2. Evaluation Description of Baseline

The office space has a glazed are between 10% and 25% of the above-grade wall area. The above-grade walls are CMU walls, while the roof is flat. According to both NY ECCC 2002 and 2007, the baseline is:

- R-11 wall assembly
- R-35 wall assembly separating office space and the refrigerated warehouse
- R-19 roof assembly for continuous insulation on a metal joist/truss roof

2.3.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.3.4. Application Description of As-Built Equipment and Operation

The project documents do not provide details on the installed insulation type. According to the document provided by the site contact, the as-built equipment consisted of the following:

- 2-in minimum rigid insulation on existing CMU wall, R-13 equivalent
- 4-in insulated wall panel on partition separating the office and refrigerated warehouse, R-35 equivalent
- 6-in Total Urethane insulation above the roof deck, R-37.1 equivalent

2.3.5. Applicant Energy Savings Algorithms

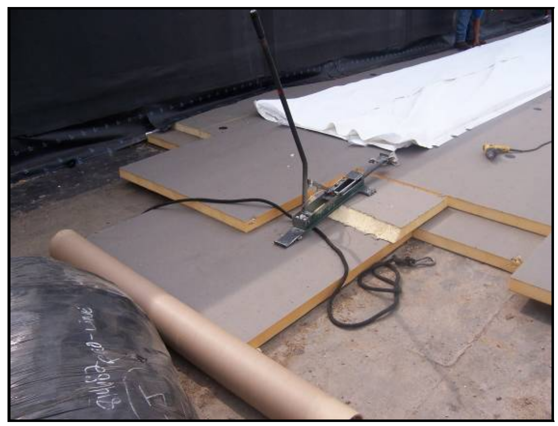
The savings have been calculated using TRACE 700 v6.1.2. Simulation input files were not made available for this project.

2.3.6. Evaluation Energy Savings Algorithms

As indicated on section 2.1.7 above, we will collect data needed to create a model of the office space area so that we can estimate the gas savings associated with the installation of the wall and roof insulation. The site contact provided us with pictures taken when the roof insulation was installed. He also indicated that the walls have been insulated with 2 inches of rigid insulation.

2.3.7. Data Measurement Method

The photos below show the installation of the insulation.



Variable	Claimed	Evaluation Inspection	Reasonable Long Term Range
Wall insulation material	2-in rigid	2-in rigid	
Roof insulation material	6-in urethane	6-in urethane	

2.3.8. Site Sampling Strategy

Sampling was not required for this measure.

2.3.9. Uncertainties

There is uncertainty associated with the estimated operating hours of the RTUs.

2.3.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

NYSERDA program documents indicate overall savings of 1,777 therms/year without disaggregation by measure. This evaluation estimated 1,216 therms/year of savings.

Evaluators do not have access to the original Trane Trace 600 model. The combination of program documents and site contact-provided project documents suggest but do not explicitly confirm that the *ex ante* analysis uses the same input parameters for baseline and retrofit RTU thermal efficiency, DCV presence, and roof insulation R-value as this *ex post* analysis. An evaluation site inspection validated equipment installation.

It is impossible to speculate on the difference in savings by measure. Overall, evaluators had the following advantages:

- Knowledge of the actual equipment schedules and loads when modeling the building.
- Spot load observation at certain weather conditions for point reconciliation.
- Reconciliation of building annual gas use with actual billing data (whereas the ex ante models for this new construction project had to project use).
- The evaluation, limited in scope and focusing on gas savings only, used a simpler bin-based analysis instead of the more comprehensive Trace.

3.2. Deviations from Plan

We could not verify the DCV installation.

3.3. Recommendations for Program Designers & Implementers

The evaluation for new construction projects would be more accurate if the project documents would provide savings estimates for each measure and the baseline and as-built systems operation.

3.4. Customer Alert

The site contact was helpful, but unfortunately he was not familiar with the HVAC system that serves the office area. Due to the nature of their business he is focused on the warehouse refrigeration system.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit *(skip for process measures)*	26,000 ft^2
Building predominant year of construction	2007

3.6. Evaluation Dates

Assignment date	
Plan approval date	
Site visit date(s)	3/5/2010
Draft site report completion date	3/23/2010

3.7. Checklist

Report submission package includes:

☑ This report

☑ All analysis spreadsheets or model input files

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

NC36

5/19/2010

SUMMARY INFORMATION

Project ID	NC36
Program Being Evaluated	NCP
Customer Name	
Site Name If Different	
Site Address	
Building or Site Type	New Construction
Customer Business/Product	Car dealership

Principal Site Contact			
Title			
Phone			
NYSERDA Representative			
Phone			
Third Party Contact			
Title			
Company			
Phone			

Lead Evaluation Engineer	George Sorin Ioan
Plan Author	George Sorin Ioan

1. PROJECT SUMMARY

This project involves the construction of a new car dealership. The facility includes offices, a showroom, and maintenance bays. The project consisted of installing seven energy efficiency measures that impact the electric energy and three measures that impact the gas use. Only the three measures that impact gas use are included in this evaluation. These measures are the installation of heat recovery ventilators, high efficiency rooftop units, and demand control ventilation. The applicant reported that 8,708 therms have been saved by implementing the three gas measures.

1.1. Savings

Meas. ID	Measure Name		Energy Savings (kWh/yr)	Demand Savings (kW)	Gas Savings (MMbtu/yr)	Incentive Value ($)
1	Heat recovery	Reported	-	-	836.4	-
		Evaluated	-	-	1220.1	-
		Realization Rate	-	-	146%	-
2	High efficiency DX rooftop units	Reported	-	-	11.8	-
		Evaluated	-	-	25.4	-
		Realization Rate	-	-	215%	-
3	Ventilation control	Reported	-	-	22.6	-
		Evaluated	-	-	31.1	-
		Realization Rate	-	-	137%	-
Total		Reported	-	-	870.8	$148,273.5
		Evaluated	-	-	1,276.6	-
		Realization Rate	-	-	147%	-

All measures in the project except the heat recovery measure received SBC/SWP funding and therefore associated electric savings was excluded from this analysis. Electric energy associated with the gas-funded heat recovery measure is much less than 10% of the gas savings due to the passive design and thus is not addressed for in the evaluation analysis.

1.2. Measure Sampling

The first two measures represent 97.4% of the total gas savings. We evaluated the savings estimates for all three measures.

1.3. Budget

Task	Hours	Cost Including Expenses	
M&V plan	16	$1,568	
On site M&V	12	$1,176	
Analysis	40	$3,920	**Site Evaluation Cost / Incentive**
Report	20	$1,960	
Total	88	$8,624	$8,624/$148,273.5

2. MEASURES INCLUDED IN THE EVALUATION

2.1. Measure ID#1: Heat Recovery

The measure consisted of the installation of three heat recovery ventilators to facilitate heat recovery from the shop area exhaust air stream to the supply air stream. The heat recovery wheels can recover up to 68% of the energy from the air being exhausted and transfer it to the outside air entering the air handling unit. Exhaust air (25,500 cfm) from the car service space is used to temper the incoming outside air to the shop area.

2.1.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

Pursuant to ASHRAE 62-2001 Table 2, 1.5 cfm/ft^2 of ventilated air is required in the car service area. Consequently 25,500 cfm of outside air is required for this space. The NYSERDA baseline includes no heat recovery for the relief air in the car service area.

2.1.2. Evaluation Description of Baseline

The two key baseline parameters for this measure are the air flow rate and the presence of heat recovery.

Section 403.3 of the NY Mechanical Code is based on ASHRAE 62-2001 Table 2 and governs minimum ventilation flow rate requirements and specifies 1.5 cfm/sq.ft. for automobile repair garages. For this space that equates to 25,500 cfm. Evaluators measured a 31,554 cfm supply through the three air handlers. The measured flow rate was used as the basis for air flow calculations with and without heat recovery.

Section 803.3.4 of the NY Energy Construction Conservation Code specifies that heat recovery is required only for constant volume multi-zone systems. Furthermore, evaluators believe that the least efficient practice commonly used for repair garages in New York is no heat recovery. Thus no heat recovery is the baseline.

2.1.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.1.4. Application Description of As-Built Equipment and Operation

The project documents indicate that the units are manufactured by Trane and that their model number is YCD301C4. During the site inspection, we collected counts and verified the model numbers of the installed equipment and its operation.

2.1.5. Applicant Energy Savings Algorithms

The energy savings for this measure are based on the installation of energy recovery ventilators. The energy savings have been calculated using the DOE-2.1E building simulation program. According to program documentation, savings will accrue during both summer and winter operation. As the rooftop AC units with heat recovery provide the full car service area's cooling load and only a portion of the car service area's heating load, the DOE 2.1E model was simulated twice for this measure to determine accurate energy savings during the heating and cooling seasons. No additional input data was available to determine the values of the simulation variables that were used to model this measure.

2.1.6. Evaluation Energy Savings Algorithms

We took spot measurements of the intake airflow on the rooftop units (RTUs) equipped with sensible heat recovery wheels. For a period of two weeks, we logged the amps drawn by the three rooftop units equipped with heat recovery wheels, the air temperature before the wheel, the air temperature after the wheel, and the supply temperature into the space.

Based on the amps drawn, we estimated the RTU operating profile and operating hours. We estimated the intake air temperature difference across the heat recovery wheel using the following formula:

$$\Delta T = T_{AW} - T_{BW}, \text{ where}$$

ΔT (°F) = Intake air temperature difference across the heat recovery wheel

T_{AW} (°F) = Intake air temperature after the energy heat wheel

T_{BW} (°F) = Intake air temperature before the energy heat wheel

In order to determine if the RTU is in heating mode, we compared the intake air temperature after the heat recovery wheel (T_{AW}) with the supply temperature into the space (ST).

In order to determine whether there was a correlation between the ΔT and the outside temperature, we regressed the ΔT against T_{BW} only for the periods the RTU was operating. We used the regression coefficients to estimate ΔT based on the outside temperature.

We used T_{BW} values only for the periods the RTU was operating to create temperature bins and at each bin we estimated the percent time (%T) the unit was in heating mode. In order to determine whether there was a correlation between the %T and the outside temperature, we regressed %T against the T_{BW}. We used the regression coefficients to estimate %T based on the outside temperature.

In order to estimate the gas savings, we performed an hourly analysis. For each hour we performed the following tasks:

- ❑ We collected TMY3 dry-bulb (DB) temperature hourly averages from NOAA for Westchester County Airport.
- ❑ Using the operating profile derived from logged data, we determined how the RTU was operating.
- ❑ Using the (DB) and the regression coefficients, we estimated the %T the RTU is in heating mode.
- ❑ Using the (DB) and the regression coefficients, we estimated the ΔT across the heat recovery wheel.
- ❑ We calculated the gas savings due to the HRU by using the following formula:

$$Q = 1.08 \text{ x CFM x } \Delta T \text{ x } \%T / \text{Eff.}, \text{ where}$$

Q (Btuh) = Energy savings due to the HRV

CFM = Intake airflow (8,500-cfm ARI rated airflow; the RTU operates at constant flow)

ΔT (°F) = Intake air temperature difference across the heat recovery wheel

(%T) = Percent time the RTU is in heating mode

Eff = Rooftop furnace efficiency (81%)

For each RTU, we added the savings estimated for each operating hour to calculate the yearly gas savings.

2.1.7. Data Measurement Method

The HVAC system is controlled by a two module building management systems. The site contact indicated that the main heating source in the shop is the furnaces that are fueled with waste-oil and that the RTUs provide heat only when the furnaces cannot keep up with the demand. He was not able to provide us with additional details on the system operation.

The three RTUs that serve the repair shop provide 100% of the outside air to the space. We took spot measurements of the airflow at the RTUs intake. We used HOBO data loggers to record the amps drawn by each of the three RTUs and logged the intake air temperature before and after the wheel and the supply temperature into the space. We recorded the data during a two-week period.

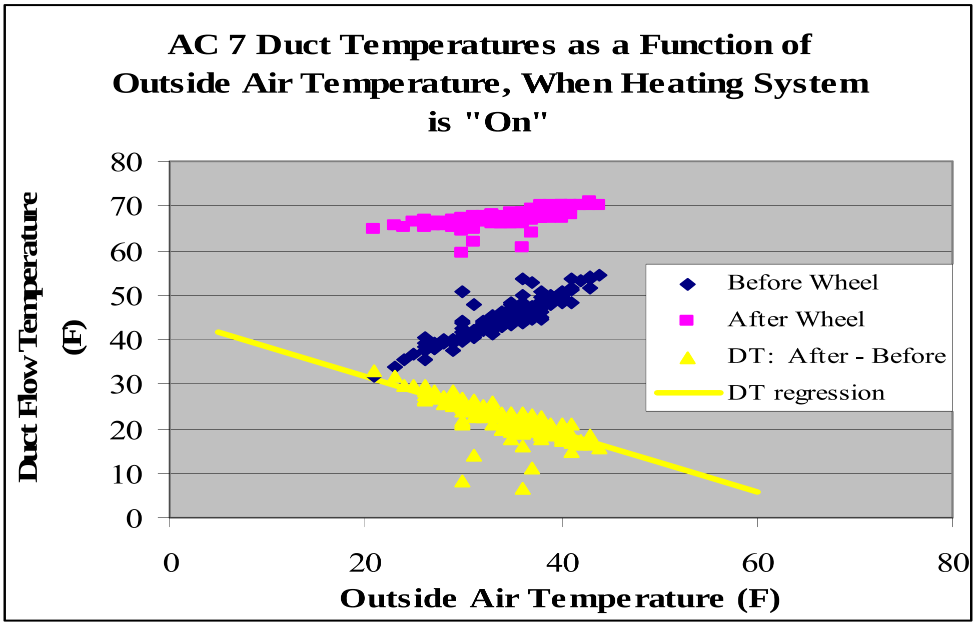
2.1.8. Site Sampling Strategy

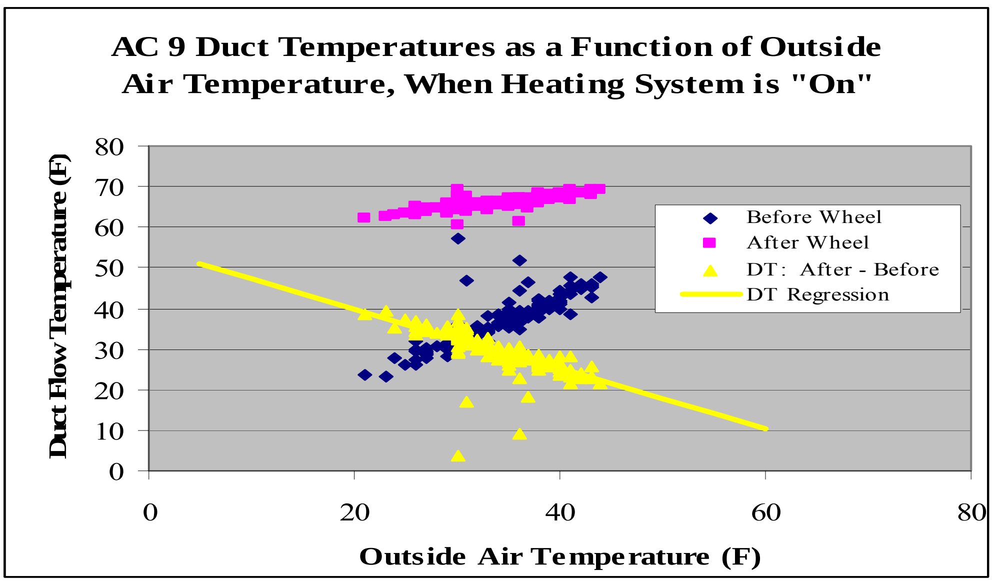
There was no sampling strategy associated with this measure

2.1.9. Uncertainties

We calculated the savings estimates assuming that the airflow intake into the RTUs was constant. The temperature measurements could have been influenced by the air stratification. During the logging period the minimum outside temperature when the units were operating was in the vicinity of 30°F and the units were in heating mode. Since we only measured the units operation when the outdoor temperature was above 30°F, we estimated that below 30°F, the units operate only in heating mode.

There is uncertainty associated with the extrapolations. The R^2s for the DT-OAT regressions were in the 0.85 to 0.95 range. The figures below illustrate the fit graphically.





The outlier points tend to be when the system is starting up or stopping.

2.1.10. Non-Energy Impacts

There are no significant non-energy impacts associated with this measure.

2.2. Measure ID#2: High Efficiency DX Rooftop Units

This measure involved the installation of packaged direct expansion (DX) high efficiency rooftop units (RTUs) with gas heating to provide space cooling and heating for ventilation to the various areas in the building. An inventory of the units and the spaces they serve is shown in Section 2.2.4 below

2.2.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

Pursuant to Table 803.2.2(4) of NYS Energy Construction Conservation Code for warm air furnaces, a minimum thermal combustion efficiency rating of 80% is required.

2.2.2. Evaluation Description of Baseline

Pursuant to Table 803.2.2(4) of NYS Energy Construction Conservation Code for warm air furnaces, a minimum thermal combustion efficiency rating of 80% is required and is the baseline.

2.2.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.2.4. Application Description of As-Built Equipment and Operation

The table below shows the units and the spaces they serve.

Unit ID	Input Capacity (MBtuh)	Space Served	Heating Efficiency %
AC-1	350	Drop-off	81
AC-2A	350	New	81
AC-2B	350	Pre-owned	81
AC-3	250	Offices	81
AC-4	150	Pick-up	81
AC-5	150	Parts	81
AC-6	150	Prep	81
AC-7	400	Shop	81
AC-8	400	Shop	81
AC-9	400	Shop	81
AC-10	80	Mezz	80

We took nameplate data from each of the above units and verified their furnace efficiency.

2.2.5. Applicant Energy Savings Algorithms

The energy savings for this measure are based on the installation of high efficiency rooftop AC units. The energy savings have been calculated by DOE-2.1E building simulation program. No additional input data was available to determine the values of the simulation variables that were used to model this measure.

2.2.6. Evaluation Energy Savings Algorithms

The savings claimed for this measure derive from the 1% increase in the RTUs furnaces efficiency. Load on ACs 7, 8, and 9 was estimated using the same approach and formulas described in section 2.1.7.

We calculated the gas savings due to the high-efficiency furnaces by using the following formula:

$$Q = 1.08 \text{ x } CFM \text{ x } (ST - (DB + \Delta T)) \text{ x } (\%T) \text{ x } (1/Eff_b – 1/Eff). \text{ , where}$$

Q (therm) = Sum of the three RTUs energy savings estimates due to high efficiency

ST (°F) = Supply temperature

DB (°F) = Outdoor temperature

ΔT (°F) = Intake air temperature difference across the heat recovery wheel

%T = Percent time the RTU is in heating mode

Eff_b = Baseline furnace efficiency (80%)

Eff = Rooftop furnace efficiency (81%)

For each of the three RTUs, we added the savings estimated for each operating hour to calculate the yearly gas savings. Then we estimated the yearly gas use of the three RTUs by using the following formula:

$$EE = Q \text{ X } Eff_b / (Eff – Eff_b)\text{., where}$$

EE (therm) = ACs 7,8, and 9 estimated yearly gas use

Q (therm) = Sum of the three RTUs energy savings estimates due to high efficiency

Eff_b = Baseline furnace efficiency (80%)

Eff = Rooftop furnace efficiency (81%)

We estimated the yearly gas used bB the other seven RTUs in the facility by subtracting the energy used by AC-7, 8, and 9 from the total energy shown on the bills.

$$EU = EB – EE. \text{ ,where}$$

EU (therm) = ACs 1, 2A, 2B, 3, 4, 5, 6, and 10 estimated yearly gas use

EB (therm) = Billed gas use

We estimated the gas used by AC 1 using the following formula:

$$EE_1 = EU \text{ X } (IC_1)/ ((\sum IC_{1\text{-}6,10}). \text{ , where}$$

EE_1 (therm) = AC 1 estimated yearly gas use

$\sum IC_{1\text{-}6,10}$ (MBtuh) = ACs 1, 2A, 2B, 3, 4, 5, 6, and 10 sum of heating input capacities

We estimated the savings due to high efficiency furnaces using the following formula:

$$Q_1 = EE_1 \text{ X } (Eff - Eff_b) / Eff_b$$

Q_1 (therm) = AC 1 energy savings estimates due to high efficiency

Eff_b = Baseline furnace efficiency (80%)

Eff = Rooftop furnace efficiency (81%)

We estimated the savings for ACs 2A, 2B, 3, 4, 5, and 6 using the same formulas as the ones used for AC 1.

We estimated the total energy savings estimates by adding the savings estimated for the ten RTUs.

Evaluators calibrated the units overall gas use based on historical billing data.

2.2.7. Data Measurement Method

We verified the nameplate data for all eleven air conditioning units. The HVAC system is controlled by a two module building management system. Ten units are set to operate in a single zone configuration, while the eleventh, AC 3, which serves the offices, is configured to operate in a multiple-zone configuration.

The main source of heat in the workshop is the waste-oil fueled furnaces, while in the drop-off area the main source of heat is ceiling radiant heaters fueled by natural gas. The site contact was not able to provide us with additional details on the system operation. We used HOBO data loggers to record the amps drawn by ACs 7, 8, and 9, we logged the intake air temperature before the and after the wheel and the supply temperature into the space. We recorded the data during a two-week period.

2.2.8. Site Sampling Strategy

The overall input heating capacity of all eleven RTUs is 3,030-MBtuh. We excluded from the evaluation unit AC 10 because its efficiency is 80%. We included in the evaluation only ten RTUs with an overall input capacity of 2,950 MBtuh. We estimated the energy savings for ACs 7, 8, and 9, which have an overall input capacity of 1,200-MBtuh and represent 40% of the overall capacity affected by this measure.

2.2.9. Uncertainties

Efficiency and efficiency improvement were accepted on a deemed basis.

We estimated that the flow of outside air into the rooftops is identical in the as-built system and in the baseline system.

There is significant uncertainty in using the metered unit with heat recovery as being representative of non-heat recovery units. Because of the small savings for this measure in both an absolute and relative sense (less than 2% of project savings, less than 200 therms/yr), this uncertainty was regarded as acceptable.

2.2.10. Non-Energy Impacts

There are no non-energy impacts associated with this measure.

2.3. Measure ID#3: Ventilation Control

The measure consisted of the installation of demand-based ventilation controls to be utilized within the facility. Demand-based ventilation was achieved by installing a carbon dioxide sensor in the space to measure CO_2 levels. These sensors send a feedback signal back to a control that interprets the signal and modulates the outdoor air dampers in response to occupancy to maintain sufficient outdoor air rates to meet ASHRAE standards. The design included demand-based ventilation for rooftop air conditioning unit AC 1 only.

2.3.1. Application Description of Baseline

The measure is reported as:

New construction or expansion	X
Replacement of failed equipment	
Replacement of working equipment	
Industrial process expansion	

There is no indication of what the application used as a baseline.

2.3.2. Evaluation Description of Baseline

The drop-off area space is the area where customers drop off their cars for maintenance or repairs. The space has two overhead doors located at each end of the space. The doors are closed when no there are no cars in the space.

Table 6-4 from ASHRAE 62.1-2007 shows ventilation rates for various spaces including parking areas. The minimum ventilation rate for a parking space is 0.7-cfm/ft^2.

Because the drop-off area is not as busy as a parking lot and is equipped with the overhead doors that provide outside air when the car enters the space, we estimated that the drop-off area would have to be provided with a ventilation rate of 0.35- cfm/ft^2. This represents 0.35 x 3750 = 1,312-cfm.

2.3.3. Seasonable Variability in Schedule and Production

Space heating is supplied only during the heating season. The project savings vary with the outside temperature.

2.3.4. Application Description of As-Built Equipment and Operation

The project documents indicate that the RTU equipped with the demand ventilation control is manufactured by Trane and that its model number is YCD181C4. We verified the model number of the RTU and verified that the CO_2 sensor was installed.

The drop-off area has two sources of heating: ceiling-mounted gas-fueled radiant heaters and heat provided by AC 1. The radiant heaters are the main source of heating, while AC 1 provides heat only when the radiant heaters cannot maintain the space temperature.

2.3.5. Applicant Energy Savings Algorithms

The energy savings are based on the installation of a ventilation control system for AC 1. The energy savings were calculated using the DOE-2.1E building simulation and analysis software. No additional input data was available to determine the values of the simulation variables that were used to model this measure.

2.3.6. Evaluation Energy Savings Algorithms

For a period of two weeks, we logged the air temperature in the mixing chamber and the supply temperature into the space.

In order to determine if the RTU is in heating mode, we compared the air temperature in the mixing chamber (MT) with the supply temperature into the space (ST).

In order to estimate the percent outside air that is supplied to the space we used the following formula:

$$\%OA = 1 - (MT - DB) / (Setpoint - OAT), \text{ where:}$$

%OA = Percent outside air supplied into the space

MT (°F) = Mixing chamber temperature

DB (°F) = NOAA recorded outdoor temperature

Setpoint(°F) = Space setpoint temperature (72 °F for occupied periods and 68°F for unoccupied periods)

We used DB values to create temperature bins and at each bin we estimated the percent time (%T) the unit was in heating mode. In order to determine whether there was a correlation between the %T and the DB, we regressed %T against the DB. We used the regression coefficients to estimate %T based on DB.

We used the same approach to determine whether there was a correlation between %OA, ST, and the DB. We used the regression coefficients to estimate %OA and ST based on DB.

In order to estimate the gas savings, we performed an hourly analysis. For each hour we performed the following tasks:

- ❑ We collected TMY3 dry-bulb (DB) temperature hourly averages from NOAA for Westchester County Airport.
- ❑ Using the (DB) and the regression coefficients, we estimated the %T the RTU is in heating mode.

- Using the (DB) and the regression coefficients, we estimated the ST.
- We calculated the gas savings due to the HRU by using the following formula:

$$Q = 1.08 \times (\%OA_{baseline} - \%OA_{as\text{-}built}) \times CFM \times (ST – DB) \times (\%T)/ Eff.,\ \text{where}$$

Q (Btuh) = Energy savings due to DCV

$\%OA_{baseline}$ = 25% (1,312-cfm / 5300-cfm)

$\%OA_{as\text{-}built}$ = As-built percent air supplied to the space

CFM = Intake airflow (5,300-cfm ARI rated airflow)

ST(°F) = Air supply temperature

OAT(°F) = TMY3 outdoor temperature

%T = Percent time the RTU is in heating mode

Eff = Rooftop furnace efficiency (81%)

We added the savings estimated for each operating hour to calculate the yearly gas savings.

2.3.7. Data Measurement Method

We installed HOBO data loggers to record the amps draw by AC 1, the mixed air temperature, and the supply temperature. We planned to install a logger to record the return air temperature but we were not able to open that section of the unit.

The data logger that was intended to record amps drawn stopped logging after two days. The recorded profile shows that AC 1 is scheduled to set back the space temperature during unoccupied periods.

2.3.8. Site Sampling Strategy

There is no sampling strategy associated with this measure

2.3.9. Uncertainties

Since we were not able to record the return air temperature for this unit, we used the space setpoint temperature to estimate the percent outside air supplied to the space.

2.3.10. Non-Energy Impacts

There are no significant non-energy impacts associated with this measure.

3. EVALUATION REPORT SUPPLEMENT

3.1. Explanation for Deviation

The evaluation savings estimates for measure #1 is 46% higher than reported. Half of the difference is likely due to the fact that the measured cfm exceeded design cfm by 20%. The other half of the difference is likely due to longer runtime.

The evaluation savings estimates for measure #2 represent 115% more than the tracking savings estimates. The difference is entirely due to our higher estimate of full-load hours based on measurement data.

The evaluation savings estimates for measure #3 represent 37% more than the tracking savings estimates. The difference is likely due to the difference in baseline ventilation rate.

3.2. Deviations from Plan

To evaluate measure 2, we intended to measure the amps drawn and mixing air temperature for other RTUs with lower heating input capacities, but due to space constraints, we were not able to install amp loggers on the units. We also planned to record the return air temperature in for AC 1, but we were not able to open that section of the unit.

3.3. Recommendations for Program Designers & Implementers

We believe that for new construction projects, it would be useful to request soft copies of input and output files used in the energy models. Also, for evaluation purposes, it would be useful to involve the installers in this process by requesting them to support the evaluators.

3.4. Customer Alert

The site contact was kind and helpful, however he did not have any knowledge about the HVAC system operation.

3.5. Contextual Data

Electricity/natural gas meter number(s) that serve equipment affected by measure	—
Total building floor area affected by retrofit	49,000
Building predominant year of construction	2008

3.6. Evaluation Dates

Assignment date	
Plan approval date	
Site visit date(s)	2/9/2010 and 2/24/2010
Draft site report completion date	

3.7. Checklist

Report submission package includes:	☑	This report
	☑	All analysis spreadsheets